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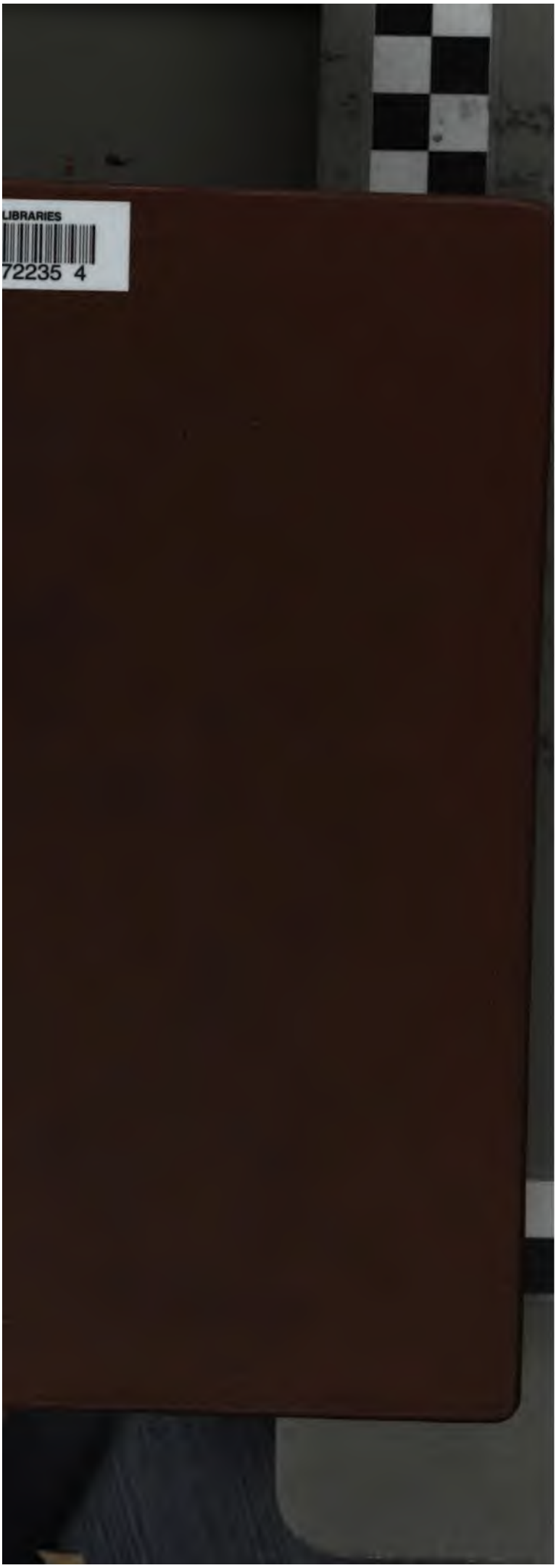
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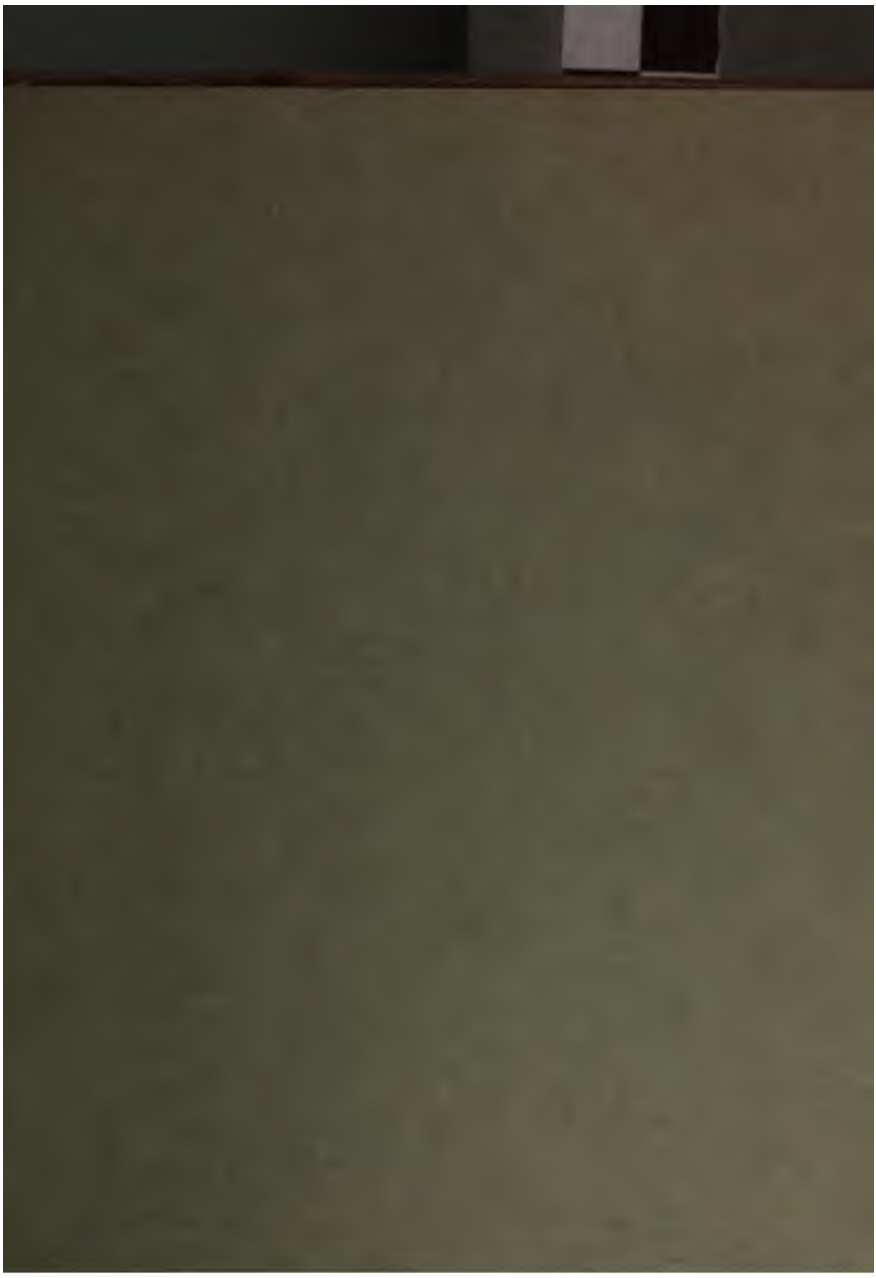

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A QUARTERLY MISCELLANY OF ENTERTAINING AND INSTRUCTIVE ARTICLES ON SCIENTIFIC SUBJECTS.

EDITED BY W. S. DALLAS, F.L.S.

ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

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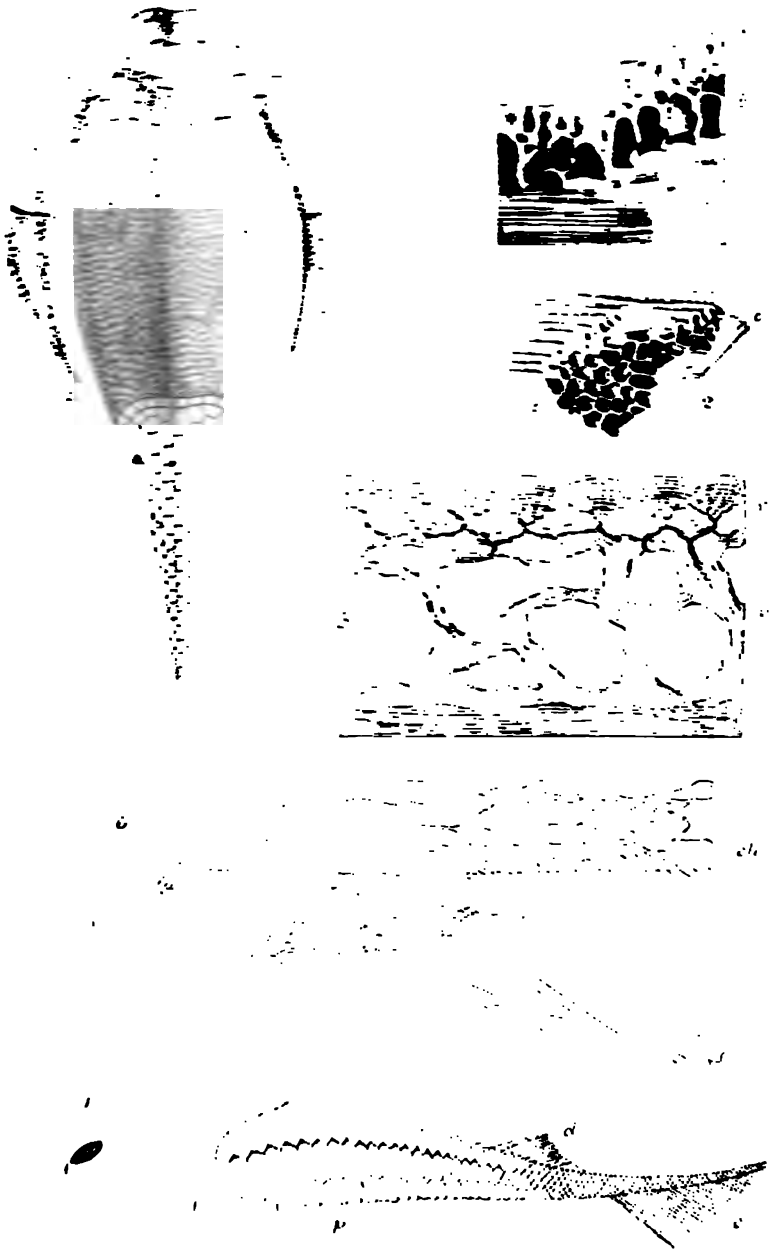


POPULAR SCIENCE REVIEW.

ON SOME ARMOURED FISHES.

By HENRY WOODWARD, F.R.S., F.G.S.

[PLATES I. AND II.]

THE doctrine of "evolution," or the tendency among animals to produce variations, which under certain conditions may survive or even supplant the parent-form, has attracted so much attention of late, that it may not be without interest to glance at some of the first representatives of the Vertebrate sub-kingdom, whose remains are left to us in the older rocks, in order to ascertain whether Palæontology affords any evidence which may be of service in elucidating this most interesting subject.

And here at the outset, it must be confessed that the oft-pleaded imperfection of the geological record leaves much untold which the naturalist seeks to discover.

Taking the class of Fishes as the earliest representatives of the Vertebrata, we naturally hope to find evidence of the first and simplest forms preserved to us in a fossil state; but the researches of the zoologist have brought to light a form now living which, from the perishable nature of its entire organism, we can never hope to find fossil; and comparative anatomy shows us that the ordinarily received notion of a vertebrate animal being one which possesses a backbone, frequently fails us from the apparent absence of this most important part!

For example, we have in the anomalous *Amphioxus* or "Lancelet" (Woodcut, Fig. 1) an animal placed with the Vertebrata, yet of the most elementary construction conceivable. Indeed, it seems paradoxical to class such a creature with vertebrate animals, seeing that it has *no skeleton*, properly so called; the bony centra of the vertebral column are represented by a

semigelatinous rod (*ch*) (the "notochord," or *chorda dorsalis* of embryologists), enclosed in a membranous sheath (*n*) supporting the spinal cord (*md*).

Fig. 1.

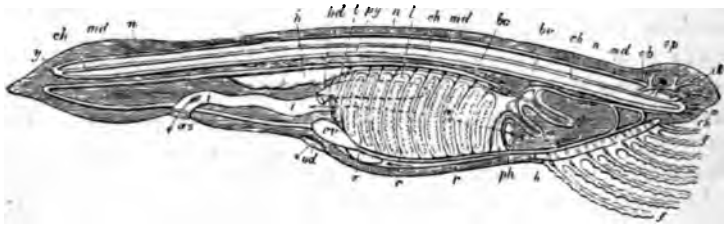


DIAGRAM OF THE ANATOMY OF THE "LANCELET," *Amphioxus*, OR *Branchiostoma* (after Owen).*

There is no skull, and the spinal cord does not expand in front to form a distinct brain or *cerebrum*. The body is lanceolate in shape, and is provided with a narrow membranous border, of the nature of a median fin, which runs along the whole of the dorsal and a portion of the ventral surface, and expands at the tail to form a lancet-shaped caudal fin. No true "paired" fins representing fore and hind limbs exist. The mouth (*b*) is a longitudinal slit, placed at the front of the head, entirely destitute of jaws, but surrounded by a number of oral cirri (*f*, *f*), which are borne by a pair of jointed cartilaginous filaments. The throat is provided with several leaf-like filaments (*g*, *g*), which are richly supplied with blood, and appear in part to discharge the function of gills. The mouth opens into a dilated chamber, termed the pharyngeal or branchial sac (*ph*).

The walls of this chamber are strengthened by numerous cartilaginous filaments (*r*, *r*, *r*), between which are transverse slits (*æ*) or clefts, not opening upon the skin, and the whole chamber is lined with a richly ciliated mucous membrane.

The water admitted by the mouth passes through the branchial clefts into the abdominal cavity, and escapes through the aperture (*as*) in the ventral surface. The alimentary canal (*i*, *i*) proceeds from the posterior end of the branchial sac; it has a sac-like organ (*h*) appended to it, which probably represents the liver.

* We are indebted to the courtesy of Messrs. Longmans & Co. for permission to use this woodcut, and also for Fig. 2, from Prof. Owen's "Comparative Anatomy, Vertebrates," Vol. I., 1866, p. 31, fig. 23, and p. 26, fig. 16.

Letters in woodcut, Fig. 1, not referred to in the text:—

ob. longitudinal filamentary ligament supporting the spinal chord; *y.* posterior termination of notochord; *bv.* branchial vein; *ba.* branchial artery; *ov.* ovarian vessel? *od.* ovarian duct? *h.* the liver? *hd.* hepatic duct; *py.* pylorus.

There is no swim-bladder, no special heart, the circulation being effected by means of several contractile dilatations—"pulsatile portal sinuses" (Owen)—developed upon the main blood-vessels. The blood is colourless. A pair of nerves are given off to the eyes (*op*), and another branch to a ciliated pit, probably an olfactory organ (*ol*).

The resemblance between the respiratory pharyngeal sac of the "lancelet" and that of the tunicated mollusks, Ascidians, or "sea-squirts," was pointed out by the late Professor Goodsir,* who also considered the "Lancelet" as allied to the Annulosa, from the simple organization of its respiratory and circulatory system.

In the more recent researches of M. Kowalevsky, he traces a close affinity between *Amphioxus* and the early stages of some Ascidians.

"Thus in *Amphioxus* are united characters belonging to the Tunicata and Annelida, and unexpected relations are revealed between the Vertebrata and Invertebrata." †

Yet even if we might consider *Amphioxus* to be, like *Ammocœtes*, an immature form, which perhaps reached a somewhat higher adult stage by a tardy metamorphosis,‡ there are many other animals besides the "Lancelet" in which the skeleton in the adult retains many of its embryonic characters, and although these are restricted at the present day to a few among the living orders of fishes, such characters were common to all the older fossil forms.

Professor Owen observes "the centrum is the most constant vertebral element as to its existence, *but not as to its ossification.* There are some living fishes, and formerly there were many, now extinct, in which the peripheral elements of the vertebra become ossified, the central one remains unossified."§

This central basis of the neuro-skeleton, as we have already seen in the case of *Amphioxus*, may attain in the adult animal to no higher condition than that in which it is laid down in the embryo of every vertebrate animal, namely, as a more or less cylindrical fibrous sheath, filled with simple cells containing jelly. In the Lamprey (*Petromyzon marinus*) cartilaginous processes strengthen the sides of the neural canal. In the Sturgeon (*Acipenser sturio*) the inner layer of the notochord has assumed the texture of tough hyaline cartilage, whilst

* "Trans. Roy. Soc. Edinb." Vol. xv. p. 259, Plate xi.

† "On Certain Genera of Living Fishes and their Fossil Affinities." By Miss Agnes Crane. "Geol. Mag." 1877, Vol. iv. p. 209.

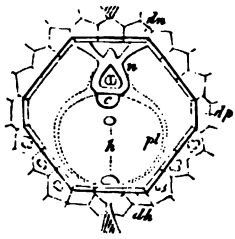
‡ *Ammocœtes*, after the third year from the egg, passes by metamorphosis to *Petromyzon*. (Owen, "Comp. Anat. Verteb." Vol. i. 1866, p. 7.) Save that *Ammocœtes* inhabits mudbanks in rivers, whilst *Amphioxus* burrows in sand beneath the sea, these forms agree closely with each other.

§ Owen, "Comp. Anat. Verteb." Vol. i. 1856, p. 30.

neural and hæmal processes of firm opaque cartilage are also present.

This absence of a solid vertebral column and bony framework does not, however, necessarily imply a poverty of lime in such animals, for many fishes in which the notochord is unossified have well-developed neural and hæmal processes, or have their heads and bodies more or less encased in stout bony plates, forming a powerful defensive armature. (See Pl. II., Fig. 1, *Coccosteus*.) Indeed, bony matter may be variously disposed in the bodies of vertebrate animals.

Fig. 2.



SEGMENT OF NEURO- AND DERMO-SKELETONS OF *Ostracion bicaudalis* (after Owen).

dn, *dp*, *dh*. dermal plates.
n. neurapophyses.
pl. pleurapophyses.

The "Trunk-fish" (*Ostracion bicaudalis*, Pl. II., Fig. 3), the Tortoise, and the Armadillo, are instances of its accumulation upon or near the surface of the body, constituting the "dermo-skeleton;" the deep-seated bones in relation to the bony-framework forming the "neuro-skeleton," being also present in these and many other instances. (See Woodcut, Fig. 2.)

It is important, however, not to confound this dermo-skeleton in the Vertebrata with the exo-skeleton in the Invertebrata.

The shells and crusts of molluscous and crustaceous animals are *unvascular*; they grow by the addition of layers to their circumference, they may be cast off when too small for the growing body, and be reproduced of a larger size. When fractured, the broken parts may be cemented together with fresh shell-substance, but are not unitable by the action of the fractured surfaces from within.

Bone, on the contrary, is a living vascular part, growing by internal molecular addition and change, and having the power of repairing fracture or other injury (Owen).

It may seem somewhat needless to recall to mind these elementary details; but in speaking of the earliest known fossil Vertebrata, it must be borne in mind that in many instances they are represented only by remains of their dermo-skeletons, the microscopic structure of which is frequently all that can be definitely relied upon to class them with the Vertebrata.

To the late Sir Roderick Murchison is due the honour of having, in company with Mr. Hugh Strickland, first discovered, in 1837, two thin "bone-beds," each little more than one inch thick, and separated by about fifteen feet of fossiliferous Upper Ludlow rock in a cutting of the Gloucester and Ross railroad. Although several of the supposed fish-remains from the

Ludlow-bone-bed"—originally described by Agassiz—have w been referred, by M'Coy, Salter, and myself, to the class ustacea, there are a sufficient number of true ichthyic frag- ntary-remains left, justly to entitle this bed to retain its imitive name.

Many of the early discoveries of fish-remains, however, have be cancelled. For example, "the defensive spine of *Onchus*," nounced in 1847 as detected in the Bala limestone by the ologists of the Government Survey; and in the same year, m the upper part of the Llandeilo Flags, by Professor Sedg- ck, are only the tail-spines of a large species of "Pod-shrimp," *ratiocaris*, a bivalved phyllopodous crustacean, nearly related the living *Nebalia*, but immensely larger in size. The same planation must be applied to Professor Phillips's "*Onchus* ines" from the Wenlock shale, and Sedgwick's fish-remains om the Wenlock limestone; whilst the *Sphagodus pristodontus* Agassiz proves to be only a part of the foot-jaw of *Pterygotus*.

As a set-off against these fossil crustaceans having been uriously elevated to the rank of fishes, it is not without terest to find that for 17 years the discovery of fish-remains the genera *Scaphaspis* and *Cephalaspis* in Cornwall and outh Devon was precluded from recognition by the decision of rofessor M'Coy, who determined them to be *sponges!* belong- g to the genus *Steganodictyum*.*

A similar incorrect diagnosis led Professors Römer and ner to refer the Cephalaspidean head-shields, from the Lower evonian of the Eifel and of Russian Gallicia, to the genus *rchæoteuthis* among the fossil cuttle-fishes. They are now laced by Lankester in the genus *Scaphaspis*; *Sc. dunensis* of e Eifel being quite closely related to *Sc. cornubicus*, from ludstone Bay, South Devon; whilst *Scaphaspis Kneri* is un- istinguishable from *Scaphaspis Lloydii*, from Herefordshire ankester).

A revision of the Cephalaspidean Fishes at the present time, esents us with 15 genera and about 53 species, some three of hich are, however, doubtful.

To Mr. John Edward Lee, F.G.S., of Torquay, belongs the nour of the discovery (in 1859) of the earliest known head- ield of a fish in the Lower Ludlow beds of Church Hill, eintwardine, Shropshire. This, the oldest known vertebrate

* Mr. Pengelly states that he has upwards of 300 fragments of *Pteraspides* m the Devonian rocks of Mudstone Bay, South Devon, which have lain his cabinet for years, having been formerly supposed to be sponges. Yet, fore 1848, Mr. Peach, the veteran geologist, had announced the discovery fish-remains in Cornwall, in the "Trans. Roy. Geol. Soc. of Cornwall," ing the identical fossils which, in 1851, Prof. McCoy called *Steganodictyum*, d referred to the Amorphozoa.

animal of which traces have been met with, is represented only by a very few imperfect specimens. It was described by the late Mr. J. W. Salter, F.G.S., in 1859 ("Annals and Mag. Nat. Hist.," Vol. IV., p. 45), and more fully in Professor Lankester's Monograph on the "Fishes of the Old Red Sandstone" (Part I., 1867, p. 25, part II., fig. 4, "Mon. Pal. Soc.," Vol. XXI.).

Fig. 3.*

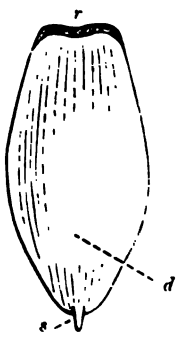


DIAGRAM OF THE SHIELD OF *Scaphaspis* (after Lankester).
r. rostrum, or rostral region.
d. central disc, or discal region.
s. posterior spine.

It belongs to the Pteraspidean division of fish-shields (for which the term *Heterostraci*† has been proposed by Professor Lankester), and to that simplest type the genus *Scaphaspis* (Woodcut, Fig. 3), in which the shield is of an oval form, and composed of a single piece about one inch and a half in length, resembling a much elongated ellipse, truncated at both ends. There is a small spine, or tubercle, near the posterior margin of the shield, the outer surface of which is marked by coarse longitudinal striæ. It is a very remarkable fact that not a trace of "osseous lacunæ" have been detected in the heterostracous head-shields. Externally, the surface, when well preserved, is covered with minute grooves and ridges, running parallel to, and concentrically with, one another. These surface-markings (Pl. I., Fig. 1, *a*) may not unfittingly be compared to the markings of the epidermis on the palms of the hands and fingers in man and other Primates. The inner surface of the shield is quite smooth and polished, and exhibits no vascular channels, as in *Cephalaspis*, only a few irregular ridges diverging from the centre of the shield, or running parallel to the margin.

Professor Huxley has minutely described and illustrated the microscopic structure of this oldest-known type of Fishes.‡ The shield is composed of three layers, the outer or "striated" layer (Pl. I., Figs. 1 and 2, *a*, *a*), the middle or "cancellated" (*ib. b*, *b*), the inner or "nacreous" layer (*ib. c*, *c*). This inner nacreous layer is made up of laminæ of about $\frac{1}{4300}$th of an inch, arranged horizontally, and is totally devoid of vascular

* For the use of this and nine other illustrations of the genera of Cephalaspidean Fishes in this paper, the author is indebted to the kindness of the Rev. T. Wiltshire, Sec. G. S., Hon. Sec. Pal. Soc.; they illustrate Prof. Lankester's Monograph in the Vols. of the Pal. Soc. for 1867 and 1869.

† From ἕτερος of another kind, and ὄστρακον a shell or dermal bone.

‡ "Quart. Journ. Geol. Soc." 1858, Vol. xiv. p. 267. Plates xiv. and xv.

canals or tubules, save where a canal of some size passes from its aperture upwards into the walls of the next layer.

In some cases these canals appear to open from the polygonal cavities of the middle layer; in other cases, they come directly from their apertures on the inner surface of the shield. In the upper wall of the stratum of polygonal cavities, the canals take a horizontal direction, still very few in number, and of large size, receiving here branches from the cavities. The calcareous laminæ are here arranged horizontally. If the section has been made transverse to the surface ridges, these appear as so many papilliform processes; or if along one of the ridges, a continuous horizontal layer is exhibited. Into this layer, or into these papillæ, the horizontal canals send short branches (one to each papilla), which give off minute tubules in every direction; these arborescent tufts (Pl. I., Fig. 3, *r*) correspond to the vascular bushes seen, under the microscope, in the external layer of *Cephalaspis*. The laminated material is arranged round these tufts concentrically, the finer branches traversing it much in the same way as dentinal tubules traverse dentine. Indeed, each of the sections of the ridges recalls very strongly the structure of a tooth, or of a dermal defence of a placoid fish. There is no trace of a "ganoin" layer beyond the laminated material forming the ridges; nor can any such layer be detected with the microscope.

The characteristic structure of these shields appears to be—the absence of bone-lacunæ, the paucity of vascular canals, and the excavation of the mid layer of the shield into large vascular sinuses (Pl. I., Figs. 1-3, *b*). It was the exposure of the inner "cancellated" layer, by the decortication of the outer "striated layer," which led Professors Kner and Römer to regard the pteraspidean shields from Russian Gallicia and from the Eifel as the remains of cuttle-bones.

After his examination of the structure of *Pteraspis*, Professor Huxley remarks*:—"No one can, I think, hesitate in placing *Pteraspis* among Fishes. So far from its structure having 'no parallel among fishes,' it has absolutely no parallel in any other division of the animal kingdom. I have never seen any molluscan or crustacean structure with which it could be for a moment confounded."

It must be borne in mind, in connection with this question, that no indication whatever of an internal bony skeleton, belonging to these fishes, has been found; and although in the other division, the *Osteostraci*†—represented by the genus

* "Quart. Journ. Geol. Soc." 1858, Vol. xiv. p. 277.

† From ὀστέον bone, and ὄστρακον a shell or dermal bone; because in this division the shell displays true bone-lacunæ as well as vascular tubuli.

Cephalaspis—we shall see that specimens have been found showing the entire body, they prove, though only by negative evidence, that such a structure did not exist.

This oldest form of fish is widely spread; specimens of *Scaphaspis* having been obtained from Upper Silurian and Lowest Devonian rocks in Gallicia, Russia; from the Lower Devonian, Eifel; from the Lower Devonian, Mudstone Bay, S. Devon; from Polperro, Cornwall; from the Lower and Upper Ludlow, the Downton sandstone, and the Lower Old Red Sandstone of Worcester, Hereford, and Shropshire; and from the Old Red of Forfarshire, Scotland. In all seven species have been described and figured.

FIG. 4.

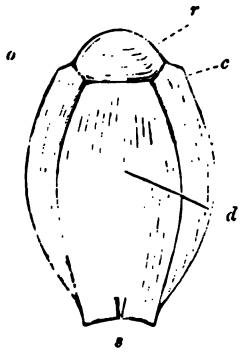


DIAGRAM OF THE SHIELD OF *Cyathaspis* (after Lankester).

o. orbits. *c.* cornua. *d. r. s.* as in Fig. 3 of *Scaphaspis*.

FIG. 5.

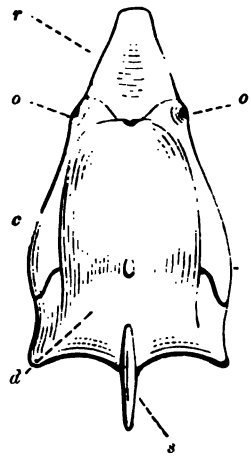


DIAGRAM OF THE SHIELD OF *Pteraspis* (after Lankester).

(Letters as in Figs. 3 and 4).

Although the shield in *Cyathaspis* (Woodcut, Fig. 4), is as simple in outline as in *Scaphaspis*, yet it betrays a tendency towards a more complex structure, being divided by sutures into a frontal or "rostral" portion, two lateral pieces (called "cornua") and a central or "discal" region. It is represented by two species only, from the Downton sandstone, and the Lower Old Red (or "Cornstones") of Herefordshire.

A new genus, named *Holaspis*, represented by a head-shield without sutures, from the Lower Old Red ("Cornstones") of Abergavenny, Monmouthshire, has lately been described and figured,* but although considered by Professor Lankester to be

* "Geol. Mag." 1873, vol. x. p. 241, plate x.

near to *Scaphaspis*, its outline and profile* are more like those of *Pteraspis*.

Pteraspis (Woodcut, Fig. 5), is the last and most highly developed of the Heterostracous fish-shields.

The shield is much more pointed than the other forms, resembling a javelin-head in shape, and is divisible by sutures into seven parts. The dorsal spine is strongly developed, and the small marginal orbits (*o*, *o*,) are distinctly visible. The palm-like wrinklings upon the surface are not unfrequently beautifully preserved.

Pteraspis has only three species, but they are found in Monmouthshire, in Shropshire, at Malvern, Worcestershire, in Herefordshire, and in Forfarshire, Scotland; all in the Lower Old Red Sandstone formation.

Professor Schmidt, of St. Petersburg, has described another Russian form, under the name of the *Trematuspis*, but we have not yet seen its figure or description.

Of the Osteostracous forms of head-shields that best known to palæontologists is the genus *Cephalaspis* (Pl. I., Fig. 4), established by Agassiz in his great work in 1835.† In this genus the posterior angles of the shield-shaped helmet are produced backwards in a pointed form, giving to the head the outline of a "saddler's knife"—"a tool with a crescent-shaped blade, and the handle fixed tranversely in its concave side. In general outline the *Cephalaspis* resembled this tool, the crescent-shaped blade representing the head, the transverse handle, the body. The head compared with the body was of great size, comprising nearly one-third of the creature's entire length. In the centre, and placed closely together, as in many of the flat fishes, were the eyes."‡ The fins consisted of two pectoral fins of very peculiar form and character (Pl. I., Fig. 4, *p*), a dorsal fin (*d*), placed very far back on the body, and a caudal fin, the rays of which are all placed inferiorly to the extremity of the body (*c*).

The pectoral fins have no trace of fin-rays or scales: they are simply ellipsoidal expanses, with some calcareous matter in their structure which has caused their preservation.

The body, which was triangular in form, was protected by four principal rows of imbricated rhomboidal scales, with a lower marginal row and probably eight rows of small ventral scales; the bony structure of these scales accords with that of the head-shield. The scales break up, and become smaller and much

* "Geol. Mag." 1873, Vol. x. p. 331 (woodcut).

† "Poissons Fossiles du Vieux Grès Rouge, ou Système Dévonien: Neufchâtel." Folio plates, 4to. text; Vol. ii. 1835, p. 149.

‡ Hugh Miller, "The Old Red Sandstone," 1847, p. 172.

more numerous as they reach the dorsal fin, and recede thence to the slender extremity of the body.

"In but few of the specimens," writes Professor Huxley,* "which I have had the opportunity of observing, has the external surface of the cephalic shield been well exhibited, or preserved over any considerable surface. Where best shown it is somewhat uneven, and presents that curious apparent division into polygonal (usually hexagonal) areæ which has been described by Professor Agassiz (Woodcut, Fig. 6). On examining the apparent sutures closely, however, they have not presented to my observation precisely the appearance figured by him. They appear rather as if short, delicate, reddish brown lines had been ruled across the line of junction of the sides of the hexagons, for some way towards the centre of each hexagon; and these lines are so gently convergent as to seem nearly parallel. Neither do I remember to have met with such strongly marked central elevations as those represented in the figure cited."

Fig. 6.

POLYGONAL ORNAMENT FROM HEAD-SHIELD OF *Hemicyclaspis Murchisoni* (after Lankester); magnified 7 diameters.

Having carefully examined numerous recent specimens of armour-plated fishes, I was much struck by the foregoing observation of Professor Huxley; as not only applicable to *Cephalaspis*, but to the dermal armour of the entire body of

Fig. 7.

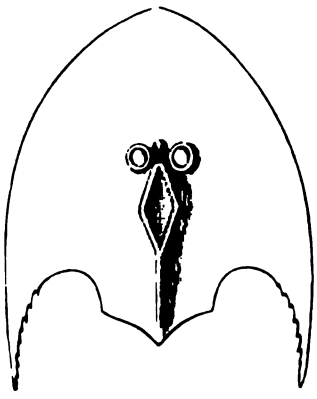


Fig. 7*a*.

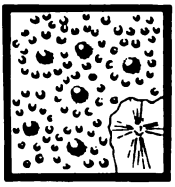
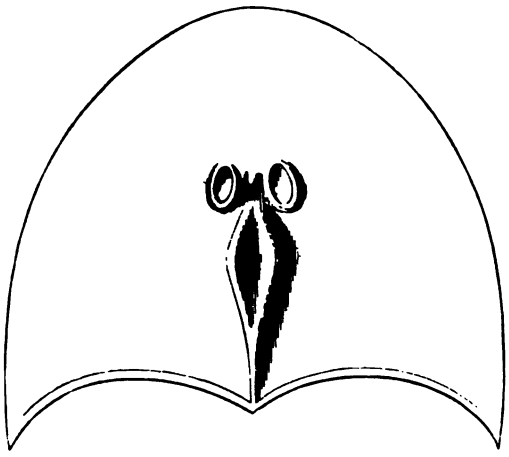


Fig. 7.—OUTLINE OF HEAD SHIELD OF *Eucephalaspis Pagei* (Lankr.).
7*a*.—ORNAMENT OF THE SAME, MAGNIFIED 7 DIAMETERS (after Lankester).

* Op. cit. p. 279.

Ostracion (Pl. II., Fig. 3, *Ostracion bicaudalis*, West Indies), drawn for comparison from a specimen in the British Museum. From the structure and form of these head-shields, and the different position of the eyes in some of them, Professor Lankester has divided the genus *Cephalaspis* into three sub-generic types, namely:—*Eucephalaspis* (Woodcut, Fig. 7), *Hemicyclaspis* (Woodcut, Fig. 8), and *Zenaspis*.

Fig. 8.



OUTLINE OF HEAD SHIELD OF *Hemicyclaspis Murchisoni*, EGERTON (after Lankester).

Eucephalaspis includes the celebrated specimen named by Agassiz after Sir Charles Lyell, in which the form of the body is very well preserved (see restoration, Plate I., Fig. 4).

Other species (*E. Powriei* and *E. Pagei*) have been added by Lankester; also showing the general form of the body, with the pectoral, dorsal and caudal fins; and the *actual* scales, which, in *E. Lyelli*, are not preserved. *Hemicyclaspis Murchisoni* best shows that very peculiar polygonal division of the surface of the carapace (Woodcut, Fig. 6), which Professor Huxley has called attention to (*ante* p. 10). This peculiar ornamentation is *not always* present, other head-shields being ornamented by tubercles of various forms and sizes. (See Woodcuts, Figs. 7*a*, 9, and 10*a*.)

The largest of these buckler-headed fishes belongs to the genus *Zenaspis*, a head-shield having been obtained by Mr. John Edward Lee, F.G.S., from the "Cornstones" (Lower Old Red Sandstone) of Herefordshire, measuring 7 inches by 7 inches.

A characteristic example of *Cephalaspis*, discovered by Principal Dawson, of Montreal, in the Devonian sandstones of Gaspé

Bay, Canada, has been described, and named after its discoverer, by Professor Lankester, in the Geological Magazine for 1870, p. 397, so that this curious genus must now be regarded as common to North America as well as to Britain. (Woodcut, Fig. 9.)

FIG. 9.

1 *Cephalaspis Dawsoni*, LANKESTER (NATURAL SIZE) DEVONIAN, CANADA.
2. PART OF SURFACE OF HEAD-SHIELD OF SAME, MAGNIFIED.

An exceedingly narrow head-shield with enormously developed lateral horns, from the Downton Sandstone (Upper Silurian) Ludlow, is named *Eukeraspis* (Woodcut, Fig. 10). The outer border of the shield in this species is furnished with irregular marginal spines of various length.

Two other British Osteostracous fish-shields have been described. One of these, *Auchenaspis* (Woodcuts, Figs. 11 and 12) is represented by two small shields (named *A. Salteri* and *A. Egertoni*); they are divided transversely into two parts: the anterior semicircular and bearing the eyes, the posterior part oblong and much smaller. The other, named *Didymaspis*, represented by a single specimen (*D. Grindrodi*) is divided like the preceding, but the anterior part is without prominent cornua (Woodcut, Fig. 13), and nearly oval in outline. The former (*Auchenaspis*) occurs in the "Tilestones" and Passage-beds at Ledbury and Ludlow; the second (*Didymaspis*) is found in the Old Red Sandstone of

Since the researches into the Fossils of the Old Red Sandstone first began in this country, probably no name has become more familiar to geologists and general readers than that of Hugh

Fig. 10.

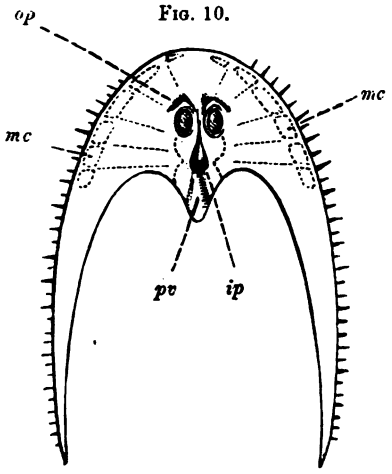


Fig. 10*a*.

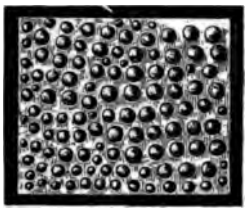


FIG. 10. OUTLINE OF HEAD-SHIELD OF *Eukeraspis pustuliferus*, AGASSIZ. *op.* orbital prominences; *mc.* marginal cavities; *pv.* post orbital valley; *ip.* interorbital prominence.

FIG. 10*a*. ORNAMENT OF SAME, MAGNIFIED 7 DIAMETERS (after Lankester).

Miller,* the self-taught naturalist, author, and stone-mason of Cromarty, whose whole career is replete with life-studies illustrative of that patient indomitable courage, which never looks

Fig. 12.

Fig. 13.

Fig. 11.

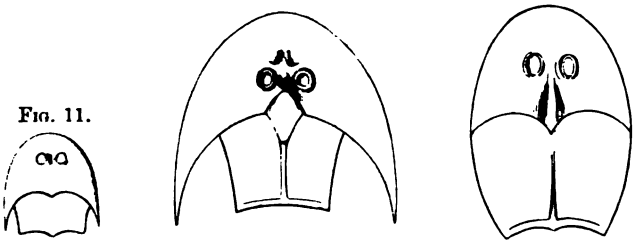


FIG. 11. *Auchenaspis Salteri* (Egerton).
„ 12. *A. Egertoni* (Lankr).
„ 13. *Didymaspis Grindrodi*, Lankr. (after Lankester).

* *See* "The Old Red Sandstone, or New Walks in an Old Field," 3rd edit. 1847. "Footprints of the Creator, or the *Asterolepis* of Stromness," 1st edit. 1849. "The Cruise of the Betsey, or a Summer Ramble among the Fossiliferous Deposits of the Hebrides."

upon any aim as unattainable that may be won by steady honest perseverance. It is especially with reference to his discoveries of those strange armour-plated fishes in these Scottish deposits that his name deserves to occupy a prominent place in the present article.

One of the most remarkable of Hugh Miller's discoveries was that of the *Pterichthys*, obtained in 1831, but only made known in 1838, and named by Agassiz, at the Glasgow Meeting of the British Association in 1840, *Pterichthys Milleri*. (Pl. I., Fig. 5.)

"When first brought to light by the single blow of a hammer, there appeared on a ground of light-coloured limestone the effigy of a creature, fashioned apparently out of jet, with a body covered with plates, two powerful-looking arms, articulated at the shoulders, a head as entirely lost in the trunk as that of the ray (or skate), and a long angular tail, equal in length to a third of the entire figure."*

A glance at our illustration forcibly reminds one of a man in a diver's dress with its windowed helmet, or of that quaint costume of *papier-maché* and metal-work, regularly worn by the Japanese night-watch only fifteen years ago!†

The head and the fore part of the body are defended by plates of hard bone, coated with enamel (thence called "ganoid plates"); those of the trunk forming a buckler, composed of a back-plate and breast-plate, articulated together at the sides. The rest of the body was defended by small enamelled bony scales, thus giving it, like the old scale-armour, at once strength and flexibility. The fish had a small back fin, and a terminal heterocercal tail-fin; but these are very rarely displayed in fossil specimens. The pectoral spines, *c*, *c*, are also formed of the same ganoid material, like the buckler. The armour of the head, or helmet, appears to have been articulated by a movable joint to the trunk-buckler.

The pectoral spines consist of two principal joints or segments, both defended by finely tuberculated ganoid plates, like those of the head and trunk. From their form they would seem to have served to aid the fish in shuffling along over the sandy bottom or bed of an estuary if left dry at low water. The fins attached to the flexible part of the body indicate a certain power of swimming, though not with any great rapidity; they include a small dorsal and a pair of ventrals; these latter were first observed by Sir Philip Grey-Egerton. The jaws are small, and are armed with confluent denticles. (Owen.)

* *See* "Life of Hugh Miller." By Sir David Brewster.

† Now only to be seen in Museums or in private collections of arms and armour. One is just now for sale, at Wright's, 90 Great Russell Street, being part of the Whitworth collection of armour.

We come next to the genus *Coccosteus** of Agassiz, in which, as in *Pterichthys*, already noticed, the dermal armature was composed of numerous plates, soldered together at their sutures, like "trusty knight in armour dight"—furnished with both back and breast-plate well rivetted together.

The external surface of these bony buckler plates in *Coccosteus* is ornamented with small hemispherical tubercles; from this fact the generic name, signifying "berry-bone," is derived. The similarity of this ornamentation to that of the plates of the buckler in some tortoises led to the belief, when these coccosteal plates were first discovered, that they were evidence of the presence of Chelonians in the Devonian beds. They have even been regarded at one time as parts of some crustacean carapace.

Alluding to Pander's restoration (Pl. II., Fig. 1), Professor Owen remarks :† "If a heterocercal fin were added to the restoration, a correct idea would be given of the Old Red fossil, which, in the progress of its construction, has suggested such diverse notions of its nature and affinities.

"The helmet and cuirass are firmly united, and there is no trace of the jointed appendages, like pectoral fins, which characterize *Pterichthys* (Pl. I., Fig. 5, *c*, *c*). The unprotected part of the trunk shows an ossification of the neural and hæmal spines (*n* and *h*), and of their appendages, the rays of the 'dorsal' and 'anal' fin (*d* and *a*); and by the analogy of *Cephalaspis* (Pl. I., Fig. 4), the tail was most probably terminated by an unequal-lobed fin (*c*). The lower jaw is composed of two rami, loosely connected at the symphysis; so that being displaced and crushed in fossil specimens, they gave rise to the notion of the fish being provided with laterally-moving jaws, like those of the lobster. But the lower jaw worked vertically upon a fixed upper one; both jaws being provided with from ten to twelve teeth on each side, anchylosed to the bone."

The blank space (*ch*) seen in fossil specimens, between the neural (*n*) and hæmal (*h*) spines, indicates the position of the soft "notochord" which has been dissolved away. The cylindrical gelatinous body, so-called (in Latin *chorda dorsalis*), exists before the formation of the bony bodies, or *centra*, of the vertebræ in all vertebrate animals: and the development of those bodies seems never to have gone beyond this embryonal phase in any palæozoic fish. Hence they have been called "notochordal" fish, on account of their retaining the notochord. (Owen.)

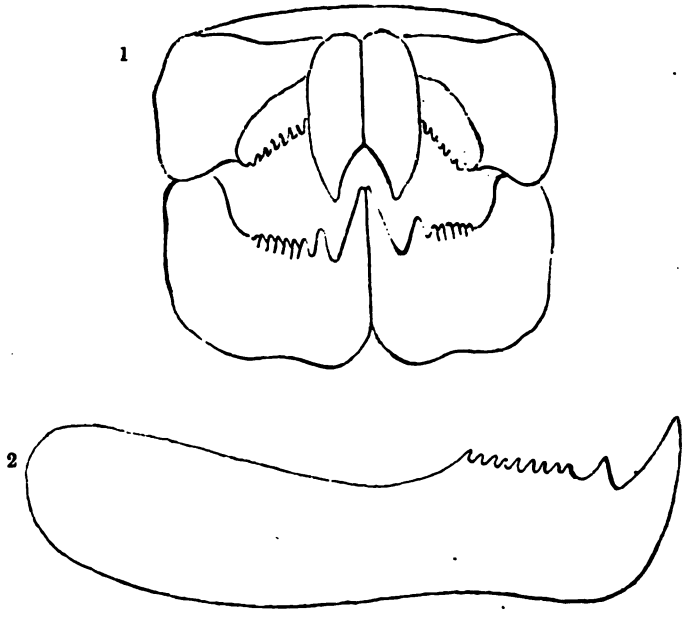
* So called from κόκκος a berry, and ὀστέον bone, in allusion to the surface of the plates being everywhere covered with small berry-like tubercles. (*See* Woodcut, Fig. 10*a*, *Eukeraspis*, but which conveys a good idea of the surface ornamentation of *Coccosteus*.)

† "Palæontology," p. 145.

Closely allied to Agassiz's genus *Coccosteus*—if not probably identical with the great Cromarty fish discovered by Hugh Miller, but of far more gigantic proportions—is the great Placoderm described by Professor Newberry* from the Upper Devonian Black Shales of Delaware, Ohio.

This enormous armour-plated fish, for which the name *Dinichthys* has been proposed, deserves the same distinction among fishes as the Dinosaurians among Reptiles, and the *Dinornis* among birds.

FIG. 14.



1. ANTERIOR ASPECT OF HEAD OF *Dinichthys Herzeri* ($\frac{1}{8}$th natural size).
2. MANDIBLE OF SAME ($\frac{1}{8}$th natural size).

Most of the bones obtained belonged to the head, which was about three feet in breadth and nearly three inches in thickness, being strengthened at the occiput with internal ridges. The jaws were each two feet in length. The external surface of the bony plates is ornamented with very fine vermicular markings. The body is estimated to have been about 15 feet in length.

The anterior part was protected, as in *Coccosteus*, by huge dorsal and ventral shields; and from the absence of scales, it

* State Reports, "Palæontology of Ohio," Vol. ii. "Geol. Mag." 1868, Vol. v. p. 184, and 1877, Decade ii. Vol. iv. p. 213.

1

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W. West & Co. imp.

Coccosteus. 2. Ceratodus. 3. Ostracion.

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seems probable that the rest of the body was only covered with a tough skin. Like the modern sheat-fish of the Ganges, it may have protected itself by burrowing in the mud and watching for its prey, with only its mail-clad parts exposed.

The powerful dentition of *Dinichthys* is suggestive of its carnivorous habits; and being so heavily weighted by the thick shields encasing its vital organs, it would be compelled to obtain food rather by cunning than by swift pursuit. These heavily armed Placoderms had only a comparatively short range in time, remains of the group being found only in the Upper Silurian and Devonian rocks. Thus it seems, as though unable to cope in the struggle for existence with the lighter armed and more active race of ganoids which predominated in the Devonian waters, they died out, leaving no immediate descendants.*

Dinichthys, like *Coccosteus*, appears to have had an unossified notochord.

But besides the "Lancelet" (*Amphioxus*)—the most lowly organized of existing vertebrates—three genera, belonging to the highest order of fishes—the Dipnoi (or double-breathers)—living at the present day, all exhibit the same embryonal structure in the adult state, namely, the *Lepidosiren* found in the Amazons, South America, the *Protopterus* of the African rivers, and the *Ceratodus* (Plate II., Fig. 2) of the Australian rivers.

These remarkable fishes have the swim-bladder modified into true internal lungs, whilst they retain internal branchiæ, so that they are capable of existing either in the water or on land. During the rainy season, large rivers like the Amazons and the Gambia are subject to overflow, whilst those of the Australian continent are not only liable to overflow, but are subject to long continued periods of drought, during which the waters sink so low that the beds of the rivers are frequently dry, and water is only found in deep hollows ('waterholes') or in muddy pools. The *Protopterus* and *Lepidosiren* bury themselves in the mud, and breathe by means of their lungs until the return of the rainy season sets them free once more to pursue an aquatic existence. The *Ceratodus*, if unable entirely to subsist without water, can nevertheless live in water so muddy as to be unfit for branchial respiration, and to come to the surface and breathe air direct by means of its modified swim-bladder. But Dr. Günther†

* A. Crane, "Geol. Mag." 1877, Vol. iv. p. 214.

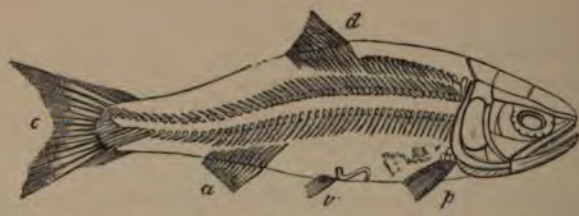
† "Description of *Ceratodus*, a Genus of Ganoid Fishes, recently discovered in the Rivers of Queensland, Australia." By Dr. A. Günther F.R.S. "Phil. Trans." 1871. Part II. p. 511.

is of opinion that *Ceratodus* is not adapted to quit the water entirely, the limbs being much too flexible to support so heavy and unwieldy a body, and too feeble to be of much use in locomotion on land.

Ceratodus belongs to a most ancient order of fishes, and is represented in the Oolitic and Rhætic beds, and in the Trias and Coal-measures, by fossil teeth almost identical with those of the living Australian lump-fish.

Whilst dwelling on the persistence of embryonic characters in the adult, it is interesting to observe that in an extinct group of homocercal fish of the family Caturidæ, (Woodcut, Fig. 15) characteristic of the Oolitic and Liassic periods,* all the species are homocercal and *notochordal.*

FIG. 15.†



Caturus furcatus, OOLITE, SOLENHOFEN (after Owen).
p. pectoral; *v.* ventral; *a.* anal; *d.* dorsal; *c.* caudal fin.

We have already pointed out that in the earliest shield-bearing fossil fishes of the Upper Silurian epoch, the Cephalaspidæ (Placo-Ganoidei), there is no evidence whatever to show that they possessed any internal skeleton. They probably represented a group of fishes in which not only was the notochord persistent, but the neural and hæmal processes were alike wanting, as in *Amphioxus.*‡

In the Chondrostei, represented at the present day by the Sturgeon (*Acipenser*), the notochord is persistent, whilst the formation of the arches and their appendages does not pass beyond the cartilaginous stage. The head is covered by "ganoid" plates, joined by sutures, whilst detached bony plates occur in rows along the body. (See Plate I., Fig. 6.)

* *Caturus similis*, Agassiz, from the Chalk of Lewes, is a mere fragment of a jaw, to the determination of which no importance need be attached.

† For permission to use this figure (reproduced from Prof. Owen's 'Palæontology,' p. 163), we are indebted to the kindness of Messrs. A. & C. Black, Edinburgh.

‡ Or the neural processes may have had a rudimentary development, as in the Lamprey (*Petromyzon*); Marsipobranchii.

The genus *Chondrosteus* carries this type back as far as the Lias period.

In the Placodermi, represented by *Dinichthys*, *Coccosteus*, and *Pterichthys*, we have a somewhat further advance in the ossification of the neural and hæmal spines and of the appendages of the rays of a "dorsal," "anal," and caudal fin, the head and anterior portion of the trunk being, at the same time, encased in dermal bony plates.

The cartilaginous heterocercal-tailed sharks,* with partially ossified endoskeleton, and a covering of skin, toughened with shagreen, tubercles, and spines, belong to an ancient tribe of fishes whose progenitors probably date back to Upper Silurian times.

The bony pike† (*Lepidosteus*) of the American rivers, and the *Polypterus*‡ of the Nile and Senegal, are the best living exemplifications of the old bony-scaled ganoids—fishes clad in a complete suit of enamelled armour, which, beginning with *Osteolepis* in the Devonian, attained their maximum development in Mesozoic times. The vertebral column in *Lepidosteus* is more perfectly ossified than in any other fish, the vertebræ are remarkable as being opisthocœlian in type (hollow behind, convex in front).

The *thin-scaled* homocercal Caturidæ (see woodcut, Fig. 15), with well ossified head-plates, neural and hæmal appendages, and fin-rays, but with persistent notochord, seem to mark the incoming of our modern form of fishes.§

In the Cretaceous formation the Teleostian, or well ossified bony fishes, are numerous, and also fishes with flexible "cycloid" and "ctenoid" scales. The order Teleostei includes the majority of existing fishes, as well as those which made their appearance in Tertiary times.

Concerning the last and highest group of which we have spoken—the Protopteri of Owen, or Dipnoi of Müller—we venture to think a strong case might be established for removing these anomalous forms across the border-line of the class Fishes, and placing them with the Amphibia.

There is no tendency, either in *Lepidosiren*, or in *Ceratodus*, to produce those unpaired fins ("dorsal" and "anal"), or the

* *Plagiostomi* (Müller) = *Elasmobranchii* (Bonaparte).

† *Lepidoganoidei*, sub-ord. *Lepidosteidæ* (bony-scaled).

‡ *Lepidoganoidei*, sub-ord. *Crossopterygidæ* (fringe-finned).

§ "Cycloid" fish scales were noticed by Mr. C. B. Rose, F.G.S., in the Kimmeridge clay, Ely, and in Norfolk; others have been noticed by Mr. W. Davies, F.G.S., in the British Museum, from the same locality. *See* "Geol. Mag. 1864. Vol. i. pp. 92–94.

paired "branchial" fins, so characteristic of true fishes, but only those pairs of locomotory organs which are homologous with the limbs of higher vertebrate animals, namely, the "pectoral" and "ventral" fins.

Even in the Crossopterygidæ (*Osteolepis*, &c., and *Polypterus*), which present some affinities with *Ceratodus*, dorsal and anal fins are present. The double air-bladder of *Polypterus* only approximates to the reptilian-like lungs of *Ceratodus* and *Lepidosiren*. It is worthy of remark that Professor Owen, whilst retaining the Protopteri with the Fishes, prints against the order the significant word "(*Transitional*")."*

Dr. Melville, who devoted careful attention to *Lepidosiren annectens*, in 1847,† regarded it as a *true Amphibian*. For this conclusion he relied on the absence of the supra-occipital bone, the presence of the large epi- and basi-cranial bones, the non-development of the maxillary and inter-maxillary bones, and especially the enormous development of the Wernerian bones, which become subservient to mastication and are anchylosed to the expanded pterygoids; on the nostrils being double; on the existence during the adult condition of external cutaneous gills which do not occur in any fish; and on the coexistence of external and internal gills, with lungs: in other words, on its exhibiting the different modes of circulation, respiration, &c., observable in the second stage of the larva of the frog, and in *Amphiuma* or *Menopoma*, &c.

In the Amphibia of the order Labyrinthodontia, of the Upper Coal period, one genus at least, *Archegosaurus* (though probably there are others besides), has the notochord persistent, the vertebral arches and peripheral elements only being ossified: it is covered with small narrow sub-ganoid scales, and there are traces of branchial arches. The skull in its combined dermo-neural ossification resembles that of the Sturgeon and of *Polypterus*, &c. (Owen.)

In the Amphibia of the order Ophiomorpha, branchial clefts and rudimentary branchial filaments have been observed. These strange snake-like amphibians have transverse rows of "cycloid" scales imbedded in their integument. When adult respiration is carried on by lungs; the vertebræ are *amphicœlian*,‡ a character common to most fishes and to some reptiles.

Referring to the Amphibia, Professor Huxley observes, they "are distinguished from the *Sauropsida* and *Mammalia* by very

* Owen, "Comp. Anat. Verteb." 1866, Vol. i. p. 14.

† A. G. Melville, on the Lepidosiren, in Report of Brit. Assoc. Adv. Sc. 17th Meeting, 1847, Transact. Sect. p. 78.

‡ Hollow at both ends.

important and sharply defined characters. . . . From *Pisces*, on the other hand, they are distinguishable only by the characters of their locomotive apparatus. When they possess median fins and limbs, these never present fin-rays, and the limbs exhibit, *in full development*, the type of structure which obtains among the *Sauropsida* and *Mammalia*, and differ very widely from the fins of any fish at present known."*

He adds: † "With respect to the origin of the Amphibian stock itself, the following considerations appear to be of fundamental importance:—The early stages of development of the *Amphibia* do not resemble those of any known ganoid, teleostean, or elasmobranch fish, and are similar to the corresponding stages of the *Marsipobranchii*, *Myxine*, *Petromyzon*." "The skull of the tadpole has much in common with that of *Chimæra* and with that of the *Dipnoi*, *Ceratodus*, *Lepidosiren*." "The only *Vertebrata*, besides *Amphibia*, which have transitory external gills, are the *Elasmobranchii* (*Squalidæ*, *Raiidæ*, *Chimæridæ*), the *Dipnoi*, and perhaps some ganoids." "The only fishes which possess morphological (*Polypterus*) or functional (*Dipnoi*) lungs are the ganoids and *Dipnoi*." "The conclusions suggested by these facts appear to be that the *Amphibia* took their origin from some primordial form common to them, the *Elasmobranchii*, the *Ganoidei*, and the *Dipnoi*, and that the main distinction by which their earliest forms were marked off from those of the other groups was the development of that pentadactyle type of limb which is common to all the higher *Vertebrata*." "And seeing that the elasmobranch, ganoid, and dipnoous types were fully differentiated from one another in the Devonian epoch, it is reasonable to believe that the existence of the *Amphibia* as a group dates back at least as far as that remote period of the earth's history."

As bearing upon this subject it is interesting to notice that among the remarkable assemblage of Reptilia from South Africa, lately described by Professor Owen, is a Dinosaurian Reptile (*Tapinocephalus Atherstoni*) in which my colleague Mr. Davies detected the curious fact that the vertebræ, like some fishes, have an *amphicœlous* form, being almost notochordal within, owing to the imperfect ossification of their centra.

If the suggestions contained in the foregoing pages, as to the persistent notochord in early vertebrates, be of any genealogical or morphological value, then it may serve to indicate the earliest forms in each group, and even their relative development.

* "Encyclopædia Britannica," article *Amphibia*, Vol. i. 1875, p. 750.
† Op. cit. p. 770.

Thus we should have the following modifications in PISCES*:—

? Proto-amphioxus.	*Notochordal*—destitute of endo- or exoskeleton; respiratory and alimentary system rudimentary—resembling the *Tunicata*. No fossil type known.
(*First fishes actually known*).	
Cephalaspidæ.	*Notochordal*—endoskeleton absent (or rudimentary ?); exoskeleton in the form of bony head-shield and, in some, dermal scutes.
Placodermi.	*Notochordal*—peripheral processes of endoskeleton (and fin-rays) ossified; exoskeleton well developed anteriorly, both on dorsal and ventral surface.
Chondrostei.	*Notochordal*—peripheral endoskeleton cartilaginous, rudimentary; head covered by dermal plates—scutes in rows on body.
Crossopterygidæ.	*Notochordal*—peripheral endoskeleton partly ossified; dermo-cranial bones, coated with enamel; scales rhomboidal or cycloidal; fins lobate, paired, central axis of fin covered with scales; air-bladder double-celled, in some the walls are ossified.
Lepidosteidæ.	Vertebral skeleton, *perfectly ossified*; exoskeleton a complete suit of enamelled bony plates and scales.
Plagiostomi or *Elasmobranchii.*	*Vertebræ*—partly ossified, partly cartilaginous; endoskeleton chiefly cartilaginous; skin roughened with shagreen, tubercles, and spines.
(*Incoming of thin-scaled fishes*).	
Caturidæ.	*Notochordal*—neural and hæmal processes well developed; head with ganoid covering; body covered with *thin* scales.
(*Modern fishes*).	
Teleostei.	Endoskeleton well ossified; dermal covering consisting of thin "cycloid," or "ctenoid," scales.
(*Transitional forms*, or possibly *Amphibia?*)	
Protopteri or *Dipnoi.*	*Notochordal*—neural and hæmal processes ossified; only two pectoral and two ventral fins; dermal covering of cycloidal scales; functional internal branchiæ and well developed internal lungs.

EXPLANATION OF PLATE I.

FIG. 1. A portion of the test of *Scaphaspis Lloydii*; considerably enlarged, to show the form of the surface-ridges and the coarser structure of the lower layers of the shield. The piece is from near the centre of the shield. Observe the flatness of the ridges *a* = the outer, or 'striated' layer; *b* = the middle, or 'cancellated' layer; *c* = the inner, or 'nacreous' layer (after Lankester).

* These cannot be deemed to be placed in their proper classificatory order, but only to show the gradations of skeletal development.

FIG. 2. A fragment of *Pteraspis rostratus* showing well the 'cancellated layer' (*b*) with its polygonal cavities, the letters correspond with those of Fig. 1.

FIG. 3. Microscopic structure of shield of *Pteraspis rostratus*—a section cut parallel to the ridges. The vascular tufts and their connection with the polygonal cavities (*b*) are well seen (Lankester).

FIG. 4. Restoration of *Eucephalaspis Lyelli* (after Lankester). *p* = pectoral; *d* = dorsal; *c* = caudal fins.

FIG. 5. Restoration of *Pterichthys Milleri*, Ag. Old Red Sandstone, Cromarty (after Pander); *c, c*, the pectoral fins.

FIG. 6. Diagram figure of the Dermo-skeleton of the Sturgeon's head (*Acipenser sturio*), after Owen; *ch* = the persistent notochord.

EXPLANATION OF PLATE II.

FIG. 1. Restoration of *Coccosteus decipiens*, Old Red Sandstone, Russia (after Pander); *ch* the undivided notochord; *n* = neural spines; *h* = hæmal spines; *d* = dorsal; *a* = anal fin-rays; *c* = the caudal fin.

FIG. 2. *Ceratodus Forsteri*, a living Dipnoid fish found in the rivers of Queensland, Australia (after Günther).

FIG. 3. *Ostracion bicaudalis* (the Trunk-fish), West Indies. Drawn from a specimen in the Zoological Gallery, British Museum.

THE OLD AND THE NEW CHEMISTRY.

By M. M. PATTISON MUIR, F.R.S.E.

THERE have recently appeared in the *Comptes Rendus*, and in the *Archives des Sciences physiques et naturelles*, a series of communications by Wurtz, Berthelot, and Marignac upon the merits of the two systems of chemical notation based respectively upon the use of equivalents, and upon that of atomic weights.

The echoes of the old strife, once so fiercely waged by the opposing schools, have almost died away in this country; is it not possible that the lessons which the history of the warfare is fitted to teach are also beginning to be forgotten by the chemists of to-day?

Let us briefly glance backward at the page of chemical history which tells of the conflict of the atomists and the upholders of an equivalent notation.

Until the time of Black, Cavendish, Priestley, Lavoisier and his associates, chemistry can scarcely be called an exact science. Many experiments had been performed by the older chemists, and many facts had been amassed; but their experiments were for the most part vague, and their facts inexact.

The rise of quantitative chemistry necessitated the adoption of a quantitative notation.

In 1777 Wenzel determined, with very considerable accuracy, the amounts of potash and of lime which were required to neutralize given quantities of sulphuric and of nitric acid. He found that 123 parts of lime and 222 parts of potash severally neutralized 240 parts of nitric acid and 181·5 parts of sulphuric acid. Hence arose the idea of equivalency. So far as their power of neutralizing sulphuric or nitric acid was concerned, 123 parts of lime were equivalent to 222 parts of potash.

Passing over a period of about fifty years—a period fraught with all-important issues in chemical science—we find the idea of equivalency coming into general favour among chemists. The researches of Lavoisier, of Cavendish, of Berzelius, and of others had introduced an accuracy into chemical experiment

which had been unknown in the time of Wenzel. The fact of constant composition of compounds had been firmly established: careful analyses of series of compounds of the same element had shown that a number may be attached to each element expressing the relative amount of that element which combines with other elements to form compounds. This number was called the equivalent of the element.

Hydrogen and oxygen combined in the proportion of 1 to 8; hydrogen and sulphur in the proportion of 1 to 16; hydrogen and nitrogen in the proportion of 1 to 4·66. Hence 8 parts by weight of oxygen were equivalent, so far as the power of combining with hydrogen was concerned, to 16 parts of sulphur, and to 4·66 parts of nitrogen.

Hence in the equivalent notation the compounds of hydrogen and oxygen, of hydrogen and sulphur, and of hydrogen and nitrogen would be represented by the formulæ HO, HS, and HN, respectively; and the equivalents of oxygen, sulphur, and nitrogen would be 8, 16, and 4·66 respectively.

But oxygen and nitrogen form a series of well-marked compounds; the proportion of oxygen to nitrogen in the compounds was found to be (1) 8 : 14, (2) 16 : 14, (3) 24 : 14, (4) 32 : 14, (5) 40 : 14. In no member of the series were there less than 14 parts of nitrogen, the amount of oxygen being taken as 8.

But the study of the three compounds HO, HS, and HN showed that 8 parts of oxygen were equivalent to 4·66 parts of nitrogen: hence it appeared that in the lowest member of the nitrogen and oxygen compounds there were 3 equivalents of nitrogen; the formulæ of the series would then be ON_3, O_2N_3, O_3N_3, O_4N_3, and O_5N_3.

But these formulæ were not adopted. It was assumed that the true equivalent of nitrogen was 14, and that the formula of the compound of this element with hydrogen was H_3N: hence the formulæ of the compounds with oxygen became ON, O_2N, O_3N, O_4N, and O_5N, respectively.

From certain data the formula of phosphoric acid was deduced as PO_3, that of sulphuric acid as SO_3; but the amount of the former acid, expressed by the formula PO_5 was capable of neutralizing three times as much soda, or oxide of silver, as the amount of the latter acid expressed by the formula SO_3: hence the true equivalent formula of phosphoric acid should have been written $\frac{1}{3}PO_5$.

The study of reactions frequently led to the adoption of several equivalents for one and the same element: to carbon, for instance, the equivalents 3, 4, 6, 8, and 12 were given according to the compound or compounds from the composition of which the number was deduced.

These and similar facts were felt to militate against the universal adoption of a notation based upon equivalents.

In the year 1808, Gay Lussac announced the fact that there exists a simple relation between the volumes in which elementary gases combine, and also between these volumes and the volume of the product, provided that product be gaseous.

Hydrogen and oxygen combine—Gay Lussac showed—in the proportion of two volumes to one volume; the product is two volumes of aqueous vapour. Hydrogen and nitrogen combine in the proportion of three volumes to one volume; the product is two volumes of ammonia gas. Nitrogen and oxygen combine in the proportion of two volumes to one volume; the product is two volumes of nitrous oxide gas. Extended experiments have shown that, as a very general rule, two volumes of any compound gas contain 1, 2, 3, &c. volumes of the elementary gases composing the compound body; or, in other words, if we adopt two volumes of a compound as the standard, we can express the volumes of the constituent elements in whole numbers. Further, experience has shown that the number representing the smallest (relative) amount of an element in two volumes of any of its gaseous compounds, also represents the proportion, *by weight*, in which that element combines with other elements: we may call this number the *combining number* of the element. Thus, the smallest amount of oxygen in two volumes of any gaseous compound of this element—hydrogen being the unit of the scale—is 16. All known gaseous compounds of oxygen may be represented as containing 16, or a multiple of 16, parts by weight of that element. The smallest amount of nitrogen in two volumes of a gaseous compound of nitrogen is 14. All gaseous nitrogen-compounds may be represented as containing 14, or a multiple of 14, parts by weight of that element.

Hence, if we adopt two-volume formulæ, we are enabled to attach to each element a number expressing the proportion by weight in which that element combines with other elements to form compounds.

Now, in the equivalent system of notation, as strictly carried out, no such generalization was possible. The equivalents 3, 4, 6, &c. might be assigned to carbon. In marsh gas 3 parts by weight of carbon are combined with 1 part by weight of hydrogen; in ethane 4 parts of carbon are combined with 1 of hydrogen; in ethene 6 parts of carbon are combined with 1 of hydrogen. Are we to represent carbon compounds as containing multiples of 3, multiples of 4, or multiples of 6 parts by weight of carbon? We are perfectly entitled, on the system of notation by equivalents, to adopt the formula CH as expressing the composition of each of the gases already mentioned, giving to C a different value in each formula. Or, if we adopt—as was actually done—6 as the equivalent of carbon,

hen we may write the formulæ of these three bodies as C_1H, C_2H, and CH, or, to avoid fractional numbers, as CH_2, C_2H_2, and CH respectively. But these formulæ represent different volumes of the compounds. Let us take CH as the standard; let the amount of this gas represented by this formula occupy 1 volume, then the amount of the gas CH_2 represented by that formula occupies 2 volumes, the amount represented by C_2H_2 also occupies 2 volumes.

Further, these equivalent formulæ altogether fail to generalize the reactions of the compounds which they represent.

The old notation is said to be founded on facts and on facts alone. Numbers are attached to the elements representing the equivalents of these elements: the elements combine in the proportions expressed by these numbers, or by simple multiples of these numbers. But we have seen that to many elements 1, 2, 3, 4 or more equivalents may be assigned; which is the true equivalent? Further, we have seen that the old notation sometimes assigned an equivalent to an element which is really not the equivalent, not even *an* equivalent, of that element. The equivalent of nitrogen was said to be 14; but, as a matter of fact, 14 parts by weight of nitrogen are always found united with 3, not with 1 part by weight of hydrogen. The old notation made but little use of Gay Lussac's great generalization concerning combination by volume.

Lastly, the old notation very frequently failed, if rigidly carried out, to generalize the properties of the bodies to which it assigned formulæ.

I have shown that by adopting formulæ representing the weights of two volumes of compounds, and by carefully analysing series of compounds, we arrive at certain numbers which express the least (relative) amounts of the elements in the two volumes, and also the amounts of those elements which combine to form other compounds.

So far we have made no use of the idea of equivalency. But when we come to compare together the amounts of the different elements represented by their combining numbers, as deduced by the process just mentioned, we find that, judged by a certain standard, these amounts sometimes are, and sometimes are not, equivalent to each other. Thus, the combining number of carbon is 12, of oxygen 16, and of nitrogen 14. But 12 parts by weight of carbon combine with 4 parts of hydrogen to form 2 volumes of a gaseous compound; 16 parts of oxygen combine with 2 parts of hydrogen to form 2 volumes of a gaseous compound; and 14 parts of nitrogen combine with 3 parts of hydrogen to form 2 volumes of a gaseous compound. Further, $2 \times 16 = 32$ parts of oxygen are capable of replacing the hydrogen in 2 volumes of the gaseous compound of carbon

and hydrogen referred to in the preceding sentence, the resultant gas occupying 2 volumes. Hence we conclude that, so far as the power of combining with or of replacing hydrogen is concerned, the amount of carbon expressed by the combining weight is equivalent to twice the amount of oxygen expressed by the combining weight of that element, or to $1\frac{1}{3}$ time the amount of nitrogen expressed by the combining weight of that element. Or, if the letters C, O, and N represent 12, 16, and 14 parts of the elements carbon, oxygen, and nitrogen respectively, then, so far as the power of combining with or of replacing hydrogen is concerned,

$$C = 2O$$
$$3C = 4N;$$

or to put the same statement in another form:

$$C = 4H$$
$$O = 2H$$
$$N = 3H.$$

In such form as this have the long known facts concerning equivalency found a place in modern chemistry. We compare the amounts of the elements expressed by their combining weights (deduced from the two-volume formulæ of compounds) with reference to their power of replacing or of combining with hydrogen, and we arrive at certain wide and well-marked generalizations.

The new chemistry finds a place for the idea of equivalency.

If the combining number of each element be divided by the equivalent of that element, a number is obtained expressing the *valency* of the element. But we have found that an element may have more than one equivalent; the valency of an element may therefore vary. Each element has, however, a maximum valency.*

The combining numbers of the elements are deduced, it has been said, from analyses of two volumes of their gaseous compounds. But we are acquainted with very few gaseous compounds of a large number of the elements; nevertheless a number is assigned to every element purporting to be the combining number of that element. How are these numbers obtained?

In the year 1819 Dulong and Petit announced, as the result of experiment, that the specific heats of a number of elementary bodies are in an inverse ratio to the combining numbers of these bodies.

The combining numbers of mercury, sulphur, phosphorus, bismuth, &c., as deduced from analyses of gaseous compounds,

* I cannot here discuss the opposing theories of varying and unvarying valency.

when multiplied into the specific heats of these elements, yielded an approximately constant number. Specific heat × combining number = constant = 6·4. This statement was shown by Dulong and Petit to hold good for 13 solid elements. Since the time of its announcement the truth of the statement has been proved in the case of a considerable number of other elements. Chemists are now, for the most part, convinced that a safe generalization may be made to the effect that combining number × specific heat = constant = approximately, 6·4.

If this statement be accepted, it follows that

$$\frac{6\cdot4}{\text{Spec. heat}} = \text{approximately, combining number.}$$

If, therefore, we are unable to find a series of gaseous compounds of an element whose combining number we are desirous of determining, it is sufficient that we determine the specific heat of that element, and divide the number so obtained into 6·4: the result will approximately represent the combining number required. By careful analysis of one or more compounds of the element in question we shall then be able to determine with very considerable accuracy the true combining number. The specific heat of silver was determined by Regnault to be $0\cdot057 : \frac{6\cdot4}{\cdot057} = 112\cdot28$: the combining number of silver is therefore about 112. But careful analysis of silver chloride shows that this substance contains silver and chlorine in the proportion of 107·66 parts of the former to 35·46 parts of the latter. From analyses of gaseous compounds of chlorine, the combining number of this element has been determined to be 35·46: hence we conclude that the combining number of silver is 107·66. Had the specific heat determination yielded a number half of that actually obtained, we should have adopted $107\cdot66 \times 2 = 215\cdot32$ as the combining number of silver.

On the old equivalent system of notation, numbers were given to the elements, the products of which into specific heat were sometimes equal, approximately, to 3, sometimes to 6, and in a few cases to 2. No far-reaching generalization could be made expressing the relation between specific heat and equivalent number.

In the year 1820 Mitscherlich announced, as the result of careful study, that there exists a close relationship between the crystalline form and the chemical composition of compound bodies. If two compounds have a similar crystalline form they have also a similar chemical composition. This fact was applied in the determination of the combining numbers of many elements. The combining numbers of the elements in a compound being

known, and the crystalline form of that compound having been determined, it was only necessary to determine the quantity of the element whose combining number was desired, which was capable of replacing an amount of one of the elements in the compound represented by the combining number of that element, without altering the crystalline form of the compound, in order to fix the required number. Thus, the crystalline forms of copper sulphate and iron sulphate are similar: the combining number of copper is 63·2: but the amount of iron which replaces this amount of copper without altering crystalline form is represented by the number 56. Hence 56 is the combining number of iron.

If the equivalent system of notation were rigidly carried out Mitscherlich's law of isomorphism, as it is termed, remained unexplained—a fact by itself without a place in the general theory of chemistry.

The combining numbers obtained from a study of the crystalline forms of compounds are generally the same as those obtained from analyses of gaseous compounds, and from specific heat determinations. There are, however, many precautions to be taken in the practical application of Mitscherlich's generalization.

If the elements be arranged in a series, beginning with that having the least, and ending with that having the greatest combining number, many very remarkable points of connection are made manifest between the position of an element in the series and the general properties—physical and chemical—of that element. I shall point out one or two of these relations.

If the volumes occupied by masses proportional to the combining numbers of the elements be arranged in order, beginning with that element which has the smallest combining number, and if these numbers be compared with the combining numbers so arranged, it will be seen that the former numbers increase and decrease periodically with the latter. By representing the specific volumes—as they are termed—and combining numbers graphically by means of a curve, this periodic connection is rendered very manifest. Further, a connection is seen to exist between the positions of the elements on such a curve, and the physical properties of the elements. The more ductile metals are situated at the maximum and minimum points of the curve, or immediately follow those elements which are situated at these points. The more brittle metals are situated on the ascending portions of the curve, at no great distance from the points at which the maxima are reached. A relation also holds between specific volume, position on the curve, and volatility, between the same data and fusibility, &c. &c. Further, a close periodic relation is traceable between the combining numbers and the chemical properties of the elements.

The entire series of elements, arranged as described, may be subdivided into sections, and these sections are generally composed of elements bearing a close chemical analogy to one another. The valency of the numbers of many subsections increases and decreases periodically with changes in combining number and in specific volume. But it would be beyond the scope of this paper to discuss the bearings of the "periodic law of Mendelejeff" in detail. Suffice it to say that the "periodic law" evidently points to a quantitative connection between the combining numbers of the elements and the chemical (and many of the physical) properties of these bodies, and of their compounds.*

In the foregoing statements the combining numbers of the elements must be understood to mean those numbers which are based upon the two-volume formulæ of series of compounds, and which are checked by specific heat determinations, and by considerations of crystalline form.

The old equivalent numbers of the elements may be arranged in ascending order, but no general periodic connection can be traced between these and the properties of the elements.

The old chemistry refuses such generalisations as those which I have briefly indicated. It will have no dealings with two-volume formulæ, with numbers deduced from specific heat determinations, or from isomorphism; it traces no periodic connection between the numbers which it assigns to the elements, and the general properties of those elements. These things are called, by the old chemists, hypotheses; *their* system is founded on facts, and on facts alone. I suppose they mean to imply a very grave censure by the use of that word hypothesis. They seem to forget that all great advances in science have been made by the proper use of hypotheses.

But the old system does *not* confine itself to facts; else, why does it adopt 14 as the equivalent of nitrogen? why 6 as the equivalent of carbon? Why does it unite the equivalent of aluminium sulphate as $Al_2O_3.3SO_3$, when the true equivalent amount of this body is represented by the formula $Al_2O.SO_3$?

The old system deals in hypotheses as well as the new. There is, it is true, a difference between the hypotheses: the hypotheses of the old school are indefinite; they escape one when one attempts to lay hold of them; they do not admit of definite deductions being made from them. The hypotheses of the new chemistry are, for the most part, definite, workable, and allow of deductions being made from them, which deductions may be tested by an appeal to facts.

* In a paper entitled "On Chemical Classification" in the *Philosophical Magazine* for August, September, and October, 1877, I have gathered together in some detail the facts concerning this connection.

The new system tends more and more to bring chemistry under the sphere of general dynamics; the points of relation between chemistry and physics are every day being increased in number and in definiteness. The old system, in refusing the aid of those generalizations which I have briefly alluded to, tends to lessen the points of connection between chemistry and general physics, necessitates more or less the treatment of chemistry as a detached subject, and, in doing this, opposes the advance of that time when the grand idea of the unity of the sciences is to be realized.

The hypotheses, with the use of which the upholders of the modern school are taunted by their opponents, have done and are doing good work for chemical science. Has not the hypothesis of Mendelejeff necessitated the revision of the combining numbers of some of the rarer metals? and have not the recent determinations of the specific heats of these metals proved that the hypothetical numbers were more correct than those which were founded on facts (?)?

Has not the "periodic" hypothesis enabled Mendelejeff to predict the discovery of certain new elements, even to tell the probable properties of some of these elements? and has not the discovery of gallium at least rendered very probable the accuracy of his predictions?

Must we give up all these results? Must we return to mere empiricism? The difference between the old and the new chemistry is not a difference in the formulation of certain compounds; it does not consist in preferring certain numbers to certain other numbers: there is an essential difference in the fundamental methods of the two systems. To me it appears that the old system is empiric, the new scientific. Empiricism must precede science; but when we have attained to a certain degree of accurate knowledge, when we have gained a few far-reaching generalizations, to give up these and to return to isolated facts is, in my estimation, essentially opposed to the very nature of the scientific method.

I do not mean to assert that the new system is the best possible system; every day its defects are apparent. As chemistry advances, it is most evident that the system will require to be largely developed and perhaps, in portions, recast. Nor do I mean to deny that the old system has some points in its favour: there are reactions which can be more simply represented in terms of the old than in terms of the new notation. But I do think that the principles underlying the old system are principles which in their essence are opposed to true scientific advance, and that the principles underlying the new system are such as permit of great advances being made in the future, just as they have aided in the great advances of the past.

The new system seeks for as wide a basis as possible on which to rest the fabric of chemical science; the old system, by restricting itself to what it calls facts, narrows that basis so much as to render the fall of the whole structure not very improbable.

I have said that the modern system of notation is based upon two-volume formulæ, checked by specific heat determinations and by the study of crystalline forms: in many instances the specific heat and isomorphism methods are alone applicable for the determination of combining numbers. The numbers thus obtained express the (relative) amounts in which the elements enter into combination. We are justified in saying that oxygen always enters into combination in the proportion of 16 parts by weight, or a multiple of this number. It has been urged, by a distinguished chemist, that such a statement as this is not justified by the facts; that the amounts of oxygen occurring in two volumes of series of compounds are very nearly, but sometimes not exactly, multiples of 16; that the so-called law of multiple proportions has no existence apart from the atomic theory. Unless we found our notation on the theory that matter has an atomic structure and that chemical combination takes place between atoms, we have no right, it is argued, to say that the elements combine in multiples of certain fixed numbers. If the truth of the atomic theory be assumed, the "law of multiple proportions" must necessarily hold good. But it has been stated that we have no rigid experimental proof of the "law;" hence the conclusion is drawn that the atomic theory is a true theory. From the data I should rather conclude that the atomic theory is not a true theory. But I deny the data. We *have* sufficient experimental proof in favour of the generalization that the elements combine in certain fixed proportions by weight. The modern system of notation does not, I am convinced, necessitate the adoption of the atomic theory. In the preceding parts of this paper I have endeavoured to elucidate the main points of the old and new systems without referring to the atomic theory or using language which suggests such a theory.

I do not believe that we can develop a system of chemical notation (nor indeed any scientific system) which shall be absolutely free from hypotheses. The "law of multiple proportions" assumes that the apparent small divergences from the general statement which sometimes seem to occur are really due to errors of experiment. We must be content to make use of hypotheses in science; only we must test these by frequent appeals to facts, and we must always remember that they *are* hypotheses.

The combining numbers of the elements, then, generalize a great amount of knowledge concerning these bodies. But one naturally asks *why* do the elements combine in fixed proportions?

Why is there so intimate a connection between the numbers expressing the proportions in which the elements combine, and the general chemical and physical properties of these elements?

It seems hard to point out so many generalizations which may be made from facts, but to forbid us to generalize these generalizations. The molecular theory of matter—aided by the atomic theory of the chemist—professes to give some kind of explanation of the generalizations I have alluded to. And it appears to me that the rejection or acceptance of this theory must be based upon the success which attends its profession to give this explanation.

Matter, it is said, is possessed of a grained structure of some kind. A mass of matter is not a homogeneous whole, but is built up of parts, just as a brick wall is built up of individual bricks. These little parts are called molecules: when a body is heated the parts of the molecules do not part company. In chemical actions the molecules are split up; the smaller parts of matter then produced are termed atoms. Whether these are susceptible of further subdivision, or not, we do not know. From this theory certain deductions are made; very many of these deductions have been experimentally shown to be true. Among these deductions is the statement, generally known as Avogadro's law, that, "under the same conditions of temperature and pressure, equal volumes of gases contain equal numbers of molecules." Assuming the truth of this statement, it becomes very easy to determine the relative molecular weights of gaseous bodies. The weight of two volumes of hydrogen is the standard: this weight is called 2. The weight of two volumes of any other gas expresses the (relative) molecular weight of that gas. The smallest (relative) amount of an element occurring in one molecule—i.e. in 2 volumes—of any of its compounds is the maximum atomic weight of that element. In practice we generally assume this number to represent the true atomic weight.

The modern system of notation *may* therefore be regarded as an atomic notation. The two-volume formulæ become molecular formulæ; the combining numbers of the elements become atomic weights.

The constant number found by multiplying combining number into specific heat represents the atomic heat of the elements.

The crystal is a molecular structure, each compound molecule being built up of elementary atoms; the amount of one element which can replace an atom of another without altering the general form of the structure represents the weight of an atom of the replacing element. The fact that there exist intricate relations between the combining numbers and general properties of the elements receives some kind of explanation, when these numbers are regarded as the relative weights of the atoms *of the elements.*

The molecular theory teaches us to regard the molecule of a substance as a structure, as a definite whole. The old chemistry looked on chemical compounds as made up of two or more parts; it tended to the view that, when two substances unite, these substances are contained *as such* in the product of the combination. The old chemistry was always more or less a dualistic chemistry. The new chemistry rests upon a unitary basis. When two substances unite, the product is regarded as one new whole; the properties of the combining bodies are lost in those of the compound. Not that the compound is completely homogeneous; it is regarded as a structure, but yet a structure in which no one part is complete without every other, and in which the general properties of the whole are dependent upon the mutual action of all the parts. The new chemistry is, in this view of it, entirely in keeping with the molecular theory.

The introduction of the principle of substitution into chemistry led to the adoption of a unitary notation; such a notation finds a very probable explanation in terms of the molecular theory. The old equivalent notation has never been able to accommodate itself to the requirements of the unitary system; it does not find its fullest explanation in, but is rather opposed to, the idea of a molecular structure.

The molecular theory of matter is adopted by the great majority of physicists as a good and workable scientific hypothesis; the physicists find that this theory enables them to group together and to explain a greater number of facts than can be brought within the grasp of any other theory concerning the structure of matter which has yet been propounded. And is it not of the utmost importance that the fabric of chemical science should be reared from a foundation upon which rests also the whole building of natural philosophy?

Chemical facts, as well as physical facts, can be explained most fully in terms of the molecular theory: the new chemistry recognizes this; the old chemistry passes it by. Chemistry tends more and more to become a branch of dynamical science. To reintroduce the old equivalent system of notation would, it appears to me, be to render more distant the arrival of the time when it shall be possible to treat the science of the dynamics of atoms as a branch of the larger science of the dynamics of molecules.

But, nevertheless, the old system has some points in its favour; it has had—it still has—many great names identified with it. If it be really better than the new, it will again become paramount. What the investigators of Nature seek is not systems, but truth. Why, then, should we quarrel with one another?

THE GEOLOGICAL ANTIQUITY OF FLOWERS AND INSECTS.

By J. E. TAYLOR, F.G.S., &c.

NO naturalist will deny that, in every period of the earth's palæontological history, the animal and vegetable kingdoms have been correlated, no matter how lowly organized they may have been. But if the geological record is imperfect as regards the *animal* life which has peopled our globe during past ages, none will be surprised that it should be considerably more so as regards extinct *vegetable* types. The chances are infinitely against the preservation of the latter in sufficient perfection to enable modern botanists correctly to make out their relationships. The earliest plants were formed of loose vascular and cellular tissues, which readily decomposed, and were therefore difficult of fossilization. Plants do not possess such hard and comparatively indestructible parts as the majority of animals have, as teeth, bones, tests, and shells. Only a few plants have external substances capable of resisting decomposition, but such species rank low in the scale of classification, as in the case of the *Diatomaceæ*, which possess siliceous frustules or valves. The horse-tails (*Equisetaceæ*) are remarkable among plants by the large quantity of silica which enters into the tissue of their exterior; and in this respect they resemble many of the grasses, notably such gigantic species as the bamboo.

With the exception of the *Algæ*, or sea-weeds, plants are chiefly terrestrial in their habits. Even those flowering plants we call aquatic, generally grow at the margins of the land or in shallow water. The number of true flowering plants, such as *Ruppia* and *Zostera*, which live in brackish or salt-water is very few. Consequently geologists are dependent for the preservation of plants upon fewer physical possibilities than those which allow animal remains to be fossilized. Only where an extensive lake has had sediments quietly forming along its bottom, or in the estuary of some large and not too turbulent river, has it been possible for plants to be mineralized;

ıd it is in lacustrine and estuarine deposits that we find vege-
.tion most perfectly and abundantly fossilized. On the other
ınd, every geological formation abounds more or less in
ıimal remains; chiefly those of marine species which lived
ı the seas along whose floors the rocks were originally laid
ɔwn in the sedimentary state. In estuarine and lacustrine
.rata we meet with the largest number of remains of land
ıimals. Their carcases have been brought down by streams
nd rivers. The proportion of land animals thus preserved,
oth vertebrates and such invertebrate forms as insects, bears
certain proportion to the number of actual terrestrial plants
hich have also been fossilized.

If therefore the geological record is imperfect as regards
ɔssil animals, most of which were marine, it must necessarily
e so as regards plants. As to their bearing on the doctrine of
volution, less than ten years ago some of our best naturalists held
hat fossil animal remains were neutral. So little dependence
ɔuld be placed on any inference drawn from their geological dis-
:ibution, owing to the possibility of their unexpectedly being
ɔund in other strata than those to which it was supposed they
ad been limited, that philosophical naturalists preferred to
:gard palæontological evidence for the time as *nil*. But year
fter year has witnessed the discovery of new animal forms in
:rata of various ages, and in different parts of the world; and now
ıe most stubborn opponent of evolution is obliged to acknow-
:dge that the balance of evidence from fossil remains is
ecoming every day larger in favour of the new philosophy.

Much the same may be said of fossil botany. Thanks to the
alue of mineralized vegetation when it assumes the shape of
ɔal, the formations bearing it have been better studied and
cplored than any other, so that the chances of finding new
:getable forms have been greatly increased. We have
ɔmetimes to skip formation after formation before we can
ɔcept any inference drawn from the occurrence of fossil
nd plants, and we are often surprised by the contrasts be-
veen floras thus separated by extensive epochs. Thus, after
ıe abundant flora of the Coal Measures, we meet with but little
ntil we come to the Upper Cretaceous, Eocene, and Miocene
ɔrmations. Here and there in the Lias, some parts of the
olite, and the Lower Cretaceous rocks, we come upon local
ɔras, some of which, as in the case of the Upper Cretaceous
ɔras, had an extensive geographical distribution, so that any
ıferences drawn from their occurrence are much safer than
we had met with a fossil flora in one locality only. Whereas
ı the animal remains of the successive formations we can
itness group after group of marine organisms making their
ɔpearance and becoming extinct, the story of the vegetable

life of the globe is interrupted by enormous periods of time. This is due to the fact that the greatest number of the rocks with which geologists are best acquainted were formed in seas far from land, where it was impossible for land vegetation to be carried without destroying its distinguishing characters.

Notwithstanding this "imperfection," however, there are certain broad and unquestionable principles which geologists can depend upon in the succession both of animal and vegetable types. Thus we find that the simplest forms appear in the oldest formations, and the most complex and highly organized in the latest. No investigation appears likely to disprove this most important fact. Again, as regards animals particularly, and, far as can be ascertained, with plants also, the most *generalized* types of organized objects precede the *specialized* forms. If we had as good means of identifying plants from fragments as we have in the case of the higher animals, there can be little doubt we should find the same truth holding equally good in the vegetable kingdom. Modern naturalists have made some important discoveries by the light of embryology—that is, of the probable descent of any species by tracing the successive changes which it may pass through as an embryo. In this way it is found that the embryo of a mammal passes through an enormous number of stages, from those representing single-celled infusorial animalcules upwards and onwards through others corresponding to fish, amphibian, reptile, and bird. These embryonic stages are a kind of condensed evolution, taking place and succeeding each other in a few months instead of in millions of years, and occurring in the life history of one animal instead of an incalculable series. Embryology therefore is regarded as illustrative of palæontological evolution.

But here again animal structures give a greater advantage to the student of their history and relationships than plants. The latter have fewer embryological stages through which we can trace their probable lines of descent. This has been attempted by a few English and German naturalists, and with considerable success, but the subject remains an almost unworked field. The most suggestive probabilities as to the origin of some of the leading orders of flowering plant come from a quite unexpected quarter, namely, their monstrosities or teratology. Thus, we find that frequently the *abnormal* conditions or monstrosities of one order of plants correspond to and assume many of the characters distinctive of another order. In this way it is possible some orders may have arisen through adventitious changes in structure brought about by changes in the physical surroundings, such as climate, moisture, and height above the sea-level.

The correspondence in the mode of succession of animal and

vegetable remains, as everywhere revealed by the study of geology, renders it very probable that we have hit upon the true order of appearance on our globe. Such terms as were used by the older geologists, as the "age of fish," the "age of reptiles," and "age of mammals," roughly express this method of succession. And beyond modifications in the hard and fast lines where they made these animals to come in or disappear, nothing has been discovered to interfere with the arrangement. Corresponding to this was the classification of the vegetable kingdom, based on fossil remains, founded by Brongniart many years ago, of the "age of acrogens" (or ferns), "age of gymnosperms" (or conifers), and "age of angiosperms" (true seeding-plants). In both kingdoms, animal and vegetable, there is the strongest evidence—evidence which every new discovery strengthens—that the lower preceded the higher, and the general the special forms.

Brongniart's simple classification of the geological order of succession of the three most prominent of vegetable types upon the earth, ought not to lead the student to infer that during the "age of acrogens" or ferns, there were no conifers, or that, when the "age of gymnosperms" prevailed, there existed no true seeding or angiospermous plants. The classification indicates only the prevailing groups of vegetation. These can be again divided, so that we find the order of classification corresponds to that of palæontological succession. Thus up to the conclusion of the Silurian period, sea-weeds or *algæ* were the dominant types of vegetation; from the upper Silurian to mid-Carboniferous times, ferns and club-mosses (*Lycopodiaceæ*) were most abundant. In the Permian and Triassic periods coniferous trees were in the ascendency; then follow monocotyledonous plants, such as palms and grasses in the Oolite, and true flower-bearing plants in the Lower and Upper Cretaceous; with abundance of them in the Eocene, a preponderance of them in the Miocene strata, and so onwards to our own time. Even among the true flower-bearing or phanerogamous plants, we find that the monocotyledonous preceded the dicotyledonous; whilst the wind-fertilized (*anemophilous*) groups of dicotyledons appeared before the insect-fertilized (*entomophilous*), certainly as orderly as the Acrogens came before the Gymnosperms. For the occurrence of a few insect-fertilized plants among the first dicotyledonous flora no more invalidates this conclusion than does the fact that we find coniferous trees in the Devonian rocks interfere with their existing in the so-called "age of acrogens."

It has been recently shown that the colours of petalled or perianthed flowers exist in the first place because they are useful to plants in attracting insects; and that the visits of insects thus secured, cause pollen to be carried from one plant to another,

and so produce that degree of crossing which is beneficial. It has been found that the size and colour of the corollas of flowers (as in the geraniums), the intensity of their perfumes, or the (more practical) larger amount of honey which may be secreted in their nectaries, are always proportioned to the needs of the flowers to be crossed by pollen other than their own. So necessary is this crossing in some instances that the pistil of a flower is as barren when dusted with pollen from its own stamens as if it had been fertilized with pollen from an altogether different species. It had long been acknowledged in a general way that flowers were necessary to insects; but it is only within the last few years that it has been discovered that insects are quite as necessary to flowers. With the exception of accidental crossing, which may result from such fringe-winged insects as the minute little *Thrips* to be seen in most English flowers, the insects which can fertilize or cross different flowers, so as to make their visits important and serviceable, are limited to two or three orders. Of the orders of insects now recognized by zoologists, one may be regarded as specially adapted to flowers. This is the order Lepidoptera, a peculiarly flower-haunting group all over the world, both in the day-flying species called butterflies, and the night-flying species known as moths. Their mouths are in the shape of a trunk or proboscis, which does not allow them to suck food except in a fluid state, such as that in which we find the natural honey of plants. To this universal fact of the Lepidoptera being purely suctorial, there is only one exception in the case of the curious moths in Australia (*Ophideres*), which have boring or terebrant mouths; thus linking the Lepidoptera with other orders of insects. Next to the Lepidoptera in importance to flowers as an order, are the Hymenoptera, of which, however, only the bees are purely flower-frequenters; a good many members of this order being even disadvantageous to flowers. Among them we may instance the numerous species of ants, whose fondness for the honey secreted by flowers induces them to climb the stems of plants for the purpose of obtaining it. But as these insects are *wingless* (except a particular set at a certain time of the year, when flowers have nearly all bloomed), and as their bodies are glossy and bare of the hairy covering which in butterflies, moths, and bees enables the pollen to stick to the body, it follows that ants cannot be serviceable to flowers in crossing them; whilst if they steal the honey offered as a reward to serviceable insects, they are so far actually enemies. It is to protect flowers against such predatory excursions as those made by vigilant ants that their stems are covered with hairs and prickles, or gummy with viscid secretions. Some of the Coleoptera or beetles, such as the rose-chafers, and various

small species, are of advantage to flowers by carrying away the pollen which attaches itself to the underside of their bodies during their slow and sleepy foraging in the bosom of flowers. A few Diptera also may be useful to plants in crossing them. But enough has been said to prove that the Lepidoptera first, and such specialized forms as the bees among the Hymenoptera second, are the members of the insect world on which flowers most depend for being effectually crossed.

Now, if among all the vegetable productions of the globe those plants which bear conspicuous and attractive flowers are the latest to appear (as we have seen they are, the *anemophilous* group preceding the *entomophilous*), then, as the *Lepidoptera* are so absolutely necessary to the perfect crossing of plants, they ought to make their appearance about the same time. That is to say, if true flowers are the latest of all the developments of the vegetable world, butterflies and moths ought to be the latest evolved among the insect-tribes. Remains of insects have been found fossilized in deposits as ancient as those of the Devonian period, and from that time onwards to our own, under conditions which would have equally admitted the preservation of Lepidoptera had those insects been then in existence. It must not be imagined that, in spite of their gay colours and attractive appearance, we regard butterflies and moths as the most highly organized types of insects. On the contrary, bees, ants, and wasps among the Hymenoptera, and termites, or white ants, among the Neuroptera, by their subtle display of instinct, their knowledge of the division of labour, and the general mode in which they conduct the affairs of the hives or republics in which most of them live, recommend themselves to our notice as cerebrally the highest endowed of all forms of insect life. But the Neuroptera and Hymenoptera were in existence ages before the appearance of moths and butterflies, although it is not until the tertiary period that we find them fossilized in such specific forms (termites and ants) as leads us to believe their marvellous instincts had even then been established.

We have seen how it is possible to trace in few words the general order of succession of the leading types of animals, and also of plants. Sir John Lubbock and other philosophical entomologists believe that the various orders of insects came into existence, at different periods, somewhat as follows:—*Orthoptera* and *Neuroptera* in the Devonian epoch; *Coleoptera* during the Carboniferous; *Hymenoptera*, *Hemiptera*, and *Diptera* during the Oolitic and Cretaceous periods; and *Lepidoptera* not until Tertiary times set in. The remains of a supposed fossil butterfly have been found in the English Oolites, and named by Mr. Butler *Palæontina oolitica;* but the lepidopterous

character of the single wing thus named is doubted by Mr. S. Scudder in his work on fossil butterflies. Two other supposed secondary butterflies have been criticized by the latter author, one of which specimens he has personally examined and declared to belong to another order; and the other, which he has not seen, he does not think is lepidopterous. This examination leaves Lubbock's generalization true, for the present, that the Lepidoptera only appear in Tertiary strata. We see no reason, however, why they should not have appeared earlier, say at the beginning of the Cretaceous epoch, when true flower-bearing plants first made their appearance, although the first flowers may have blossomed more for Hymenoptera than Lepidoptera; and, indeed, the fact that the first flowers were polypetalous rather than gamopetalous—that is, had corollas made up of separate petals, rather than of the petals all joined together as we find them in the common blue-bell (*Campanula*)—is an indication that gamopetalous flowers could only be formed when there were insects with proboscides long enough to be thrust down to the nectaries at their bases, as we find them in butterflies and moths.

Thus we see there is a broad parallelism between the appearance of the more differentiated types of the vegetable kingdom, and the development or appearance of various orders of insects. Instead of the appearance of a new order, the differentiation may have been accompanied by such specialization of a large group as the bees among Hymenoptera. Mr. H. Goss has published three very important papers on the insect fauna of the primary, secondary, and tertiary periods, in which he has given the proportion of species. Of these we observe the Coleoptera or beetles are best represented. It is one of the most extensive in its geographical distribution—a fact which always indicates the antiquity of organic forms, as it proves they were spread before those physical geographical changes occurred which give the surface of the earth its present features. Among the beetles, also, we find a very extended differentiation; their genera are adapted to almost every habit of life, aquatic, subterranean, and terrestrial. They are aborted as well as developed, as in the case of the glow-worm. They live on carrion, fungi, pollen, nectar, wood, leaves, and other organic substances, and have their structures modified accordingly. Hence we cannot be surprised that the Coleoptera seem to have been from the first a dominant order, seeing how useful beetles have made themselves in the economy of the globe. Perhaps also the durability of their hard wing-cases (*elytra*) has frequently enabled them to be fossilized when other insects would have been decomposed, and thus caused them to appear numerically more abundant than contemporary orders.

We find the general distribution of insects, in geological time, to be in the order we should expect from what has already been said. The oldest fossil insect is termed by Nicholson *pseudo-neuropterous*—a name which indicates its generalized character. This occurs in the Devonian rocks of North America, but the large size of wing of one of these fossil species (indicating an expanse of five inches) leads us to infer that these Devonian forms cannot be the oldest of winged insects. Mr. Scudder regards this earliest known insect as a "synthetic type"—that is, one which combines peculiarities of structure now distributed and specialized in different groups. In the Carboniferous rocks many species of fossil insects have been met with. Among the Neuroptera we have a member of the *Ephemeridæ* or "May-flies" larger than any now known, having an expanse of seven inches of wing. These are insects which pass the first stages of their existence as aquatic larvæ. The Orthoptera are represented by very generalized forms of cockroaches, crickets, and locusts. Beetles, however, are not yet so abundantly preserved.

In the Secondary rocks large numbers of fossil insects have been found, and here beetles take the leading place. One great storehouse for them is the Lias bed at Schambelen, Switzerland. In England the Rhætic beds have yielded a rich harvest, as may be seen by a reference to the work on British Fossil Insects by the Rev. P. B. Brodie. The Purbeck beds are also locally productive of many fossil species. No *Hymenoptera* have been yet found in the Rhætic beds; but 29 species of *Coleoptera*, 12 of *Neuroptera*, 9 *Hemiptera*, and 7 *Orthoptera* from these strata have been described. Two species of beetles have been found fossilized in the Swiss Trias. Prof. Heer has discovered in the Liassic rocks of Schambelen no fewer than one hundred and forty-three species of fossil insects, which are distributed as follows: *Coleoptera* 116 species, *Hemiptera* 12, *Hymenoptera* 1, *Orthoptera* 7, and *Neuroptera* 7. The fossil beetles had even then been specialized into carnivorous types: others were leaf-feeding beetles. Some evidently lived on decaying wood; but as yet there were none which are now known to haunt flowers.

In the Stonesfield slate of England various fossil insects have been discovered. They are represented by large species of *Neuroptera*, such as dragon-flies, and various well differentiated genera of *Coleoptera*, already adapted to different kinds of food and habits of life; but none of them are flower-frequenters. It was in this bed that the supposed fossil butterfly called *Palæontina oolitica* was met with. If this be a true butterfly there must have existed flowers at the time when the Stonesfield Slate was formed, according to the theory that flowers and Lepidoptera go together. The Purbeck beds were formed in a large

[illegible] to the presence of insects; and surprisingly large numbers have been obtained from this interesting formation. The orders *Diptera*, *Orthoptera*, *Neuroptera*, and *Hymenoptera* are abundantly represented by their usual forms, mosquitoes, dragon-flies, and ants allied to existing genera. Out of sixty-four species described the beetles number eighteen. The hemipterous insects follow next, with fourteen species; the *Diptera* with twelve, and the *Orthoptera* with ten. The beetles are chiefly herbivorous kinds.

When we come to the Tertiary strata undoubted Lepidoptera make their appearance. There is no longer any zoological doubt as to what they are. But this is the period when true flowers began to be abundant, and therefore it is significant we should find specialized flower-loving insects appearing at the same time. As a rich fossil flora, containing true flowers, has been found in formations as old as the Lower Cretaceous in Greenland, it is possible that Lepidoptera appeared before the Eocene period. Nine species of fossil butterflies are found in strata of the latter age at Aix in Provence. The Miocene strata of Switzerland have yielded an immense number of species of fossil insects, which have been described by Professor Heer. In beds of this age at Radoboj in Croatia, three species of butterflies have been found; one of them singularly allied to an Indian species. In this formation the Hymenoptera are very abundant. From the Swiss Miocene at Œningen Professor Heer has obtained nearly nine hundred species of fossil insects, of which the Coleoptera number no less than five hundred and eighteen. Not only do we find these Miocene beetles differentiated and adapted to all the habits of life which their Oolitic predecessors had already possessed, but for the first time we come across true *flower-haunting* beetles, belonging to groups actually specialized in our own day to particular genera of flowers. So striking is this that Professor Heer infers the existence of such flowers (although they have not as yet been found) during the Miocene epoch. The fossil Hymenoptera of Œningen number *eighty* species, and among these are those highly specialized forms, such as bees, which are always associated with flowers. Three species of butterflies are all which have as yet been recognized. It would seem probable, therefore, that bees appeared before butterflies, and obtained their remarkable specialization by being adapted to the earliest of the flowering plants.

Near the White and Green Rivers, bordering on the territories of Utah and Colorado, an immense tertiary deposit has been explored by the United States surveyors. Its shales have been found crowded in places with insect remains, including even the

larvæ. One species of *Thrips* has been found whose minute fringed wings, characteristic of its order, are visible under the microscope. Fossil ants occur here, so that their peculiar specialization had already been effected. Only one species of moth, however, has hitherto been met with out of the sixty or seventy fossil insects described.

Later tertiary beds always contain fossil insects where the conditions are favourable to their preservation; but it would appear as if all the great orders had assumed their modern distinctiveness before the close of the Miocene period. What has since occurred has been chiefly their changed geographical distribution, and the breaking up and differentiating of two of the orders, Hymenoptera and Lepidoptera, so as to adapt many of the species of each to the most abundant or most frequented of the flowers where such insects have been distributed.

We see that a comparison of the order in which insects have appeared leads us to infer the absence of true flowers until the later geological epochs. A parallel development has taken place in insects and flowers during geological times, so as to slowly and mutually adapt each to the other. The order in which the various families of flowering plants have appeared bears a relation to that in which the different groups of insects have succeeded each other. Thus we have first the conifers and cycads, wind-fertilized plants, producing a superabundance of pollen so that some of it may surely take effect. The grasses and sedges probably appeared during the Triassic, Liassic, and Oolitic periods, although in no very great abundance or variety, or we should have more fossil remains of them than we have in the doubtful *Cyperites*. The *Antholithes* of the coal measures, once believed to be a grass, is now known to be merely a fruit-bearing spike of some coniferous plant. During the "age of conifers" a large differentiation took place in this order. There were coniferous trees living during the Carboniferous period which bore adiantum-like leaves, similar to those still produced by the peculiar conifer from Japan known as *Salisburia*, and "stone fruit," almost like plums, or rather resembling the fruit of the yew, which has long been familiar to geologists under the name of *Trigonocarpum*. These fruits are found in such abundance in some sandstone beds of the Upper Coal Measures as to make them appear almost composed of nothing else. Pines with the ordinary needle-shaped leaves, and cone-bearing, have always been abundant. The fossil plant known as *Pothocites*, found in the Scottish Coal Measures, and supposed by Carruthers to be the spike of an aroideous species, is imperfect, and some botanists deny its phanerogamous character altogether. Only eighteen species of fossil monocotyledonous flowering plants are recorded as having been dis-

covered in the three formations Trias, Lias, and Oolite, and some of these are doubtful. This proves how very scanty must have been the flower-bearing flora, for we get no similar poverty of fossil ferns or conifers. The Wealden formation was deposited as a delta at the mouth of a large river—a river watering an enormous area of country, which must have been

Fig. 1.

QUERCUS PRIMORDIALIS, UPPER CRETACEOUS BEDS, DAKOTA (after Lesquereux).

Fig. 2.

BETULA BEATRICIANA, UPPER CRETACEOUS BEDS, DAKOTA (after Lesquereux).

more or less covered with plants; and the Purbeck beds were formed along the floor of an extensive fresh-water lake. No conditions could have been more favourable for the preservation of land plants than these, yet the number of flowering

species is extraordinarily small. Remains of insects, their wings, legs, heads, &c., are preserved as we have seen; and there is no reason why we should not have found dicotyledonous flowering plants had they been abundant.

In a Greenland formation which Professor Heer calls *Lower* Cretaceous, plant beds are found which have yielded extraordinary results; 138 species of ferns, 75 of monocotyledonous flowering plants, and one dicotyledonous plant have been described. In the greater part of Europe the Cretaceous period was marked by deep-sea conditions, so that we have little expectation of finding fossil land plants. The *Upper* Cretaceous formation in many places seems to have been favourably deposited for the preservation of these desirable plants. It should be stated, however, that in the opinion of some geologists some of the so-called "Upper Cretaceous" beds, especially those of Dakota, are regarded as possibly intermediate in age between the Cretaceous and Eocene, so that they form "passage-beds" between the Secondary and Tertiary epochs. The most remarkable strata of these deposits are perhaps those of Dakota in the Western States of America, whose fossil plants have been figured and described by Professor Lesquereux. Here we find no fewer than one hundred species of dicotyledonous plants. In the Aix-la-Chapelle beds a large number of fossil leaves, &c. have enabled botanists to chronicle the incoming of many orders of plants at an earlier date than had been before imagined. In tropical Africa and Greenland plant-bearing beds of so-called Upper Cretaceous age have also been explored; and the occurrence of the remains of monocotyledonous and dicotyledonous plants in them proves how widespread and abundant these groups had already become.

All the coniferous and most of the monocotyledonous plants are "wind-fertilized"; and it is probable that up to the beginning of the tertiary epoch no such beautiful perianthed monocotyledons as the lilies, tulips, &c., had made their appearance —that, in short, all the monocotyledonous plants were up to that time "wind-fertilized." It is curious to note that when the dicotyledons first make their appearance it is also the "wind-fertilized" group which comes first. Thus, in the Upper Cretaceous beds of Dakota, out of the one hundred species of dicotyledonous plants described, no fewer than sixty-one are *apetalous*, such as the oaks, maple, &c. (see figs. 1 & 2). Many of them were catkin bearers, as the poplars. Of the remainder, thirty-five species are those possessing *polypetalous* flowers; whilst only *one* species is *gamopetalous*—that is, has flowers with the petals united into one piece. The proportion of "wind-fertilized" over "insect-fertilized" plants is always greater the further we go back in geological time, thus indicating that the "wind-

fertilized" appeared first. If we could get specimens of the entire plants, and were not forced often to depend on leaves alone for the identification of genera, there can be little doubt we should find the earliest dicotyledonous plants to belong to much more generalized types than any now existing. Such is the opinion of Baron von Ettingshausen, who has studied and compared the cretaceous and tertiary floras of the world.

The order of floral occurrence therefore is 1st, "wind-fertilized" or *anemophilous* Monocotyledons, such as grasses, sedges, rushes, &c.—gay-flowered or *perianthed* Monocotyledons not appearing for certain until the Miocene period; 2nd, Dicoty-

FIG. 3.

POPULUS LATIOR, UPPER MIOCENE, ŒNINGEN. From a specimen in the Ipswich Museum.

ledons belonging to the "wind-fertilized" division, and bearing inconspicuous flowers or catkins; 3rd, Dicotyledons with *true* flowers, but having the flowers composed of several pieces or petals (*polypetalous*); and 4th, Dicotyledons in which the petals are united, so that the flower or corolla is in one piece (*gamopetalous*). Of the *Gamopetalæ*, the *irregular* flowers, such as those of *Labiatæ*, *Scrophulariaceæ*, &c., were developed later still. The showy irregular perianthed flowers, such as Orchids, also

red among the later floral developments. This is cer-
their order of numerical proportion, and we have little
it is also that of the actual succession and appearance in
of flowering plants.
ne Tertiary epoch is that which up to a few years ago was
ed to have first witnessed the introduction of dicotyle-
s plants. We have seen that this is not the case. But
should expect from the line of argument employed, their
er becomes numerically greater as we approach the present

Fig. 4.

LOBATUM, UPPER MIOCENE, ŒNINGEN. From a specimen in Ipswich Museum.

The Eocene beds of Hampshire and elsewhere have yielded
ant remains of a flora of a nearly tropical character,
hich is on the whole related to that found in the older so-
"Upper Cretaceous" formations of Aix-la-Chapelle and
ica. The Eocene plants include many genera now deemed
arly Australian, such as the *Proteaceæ*; smilax, dryandras,
s, azaleas, cactuses, aroids, figs, &c. abounded; and their
ns are found fossilized with those of fan-palms, feather-
, and others. Climbing plants and llianes then festooned
rest trees, as they now do the woods of the West Indies.

It is in the Miocene period, however, that we have the remains of the most wonderful flora preserved, especially in the molasse beds of Switzerland. From its warm temperate character, Prof. Heer thinks the climate must then have been about sixteen degrees higher than it is now. One peculiar feature about the Miocene flora is its assemblage of existing genera which have since been rendered locally extinct, so that we now find them in parts of the world at immense distances from each other. This has been greatly the result of subsequent geographical changes, some of which, such as those occurring in the glacial epoch, were of an extraordinarily rigorous character. No fewer than seven hundred species of fossil phanerogamous plants have been obtained from the Swiss Miocene beds alone. Of these nearly three hundred were trees, and two hundred and fifty shrubs. One hundred and sixty species were herbaceous

FIG. 5.

FOSSIL FLOWER (*Parana œningensis*), UPPER MIOCENE, ŒNINGEN.
From a specimen in Ipswich Museum.

flowering plants; many of them grasses and sedges, others with showy blossoms or corollas (fig. 5). The Miocene flora plainly shows us that a great differentiation had taken place in the form and grouping of insect-fertilized plants since they first appeared. We now meet with *Composite* flowers, where we have an abortion of some and a specialization of other florets, all diminished in size and peculiarly arranged on a disk, so as to suggest the popular idea that the whole colony is only one flower, as is certainly the notion with the daisy, dandelion, and sunflower, &c. Such a modification of floral parts would only be expected by a botanist in periods subsequent to the first appearance of these flowers, and he regards them as produced by a gradual modification. *Papilionaceous* flowers, like those of the pea, remarkable for the different sizes and shapes of the petals and their different

colours—rarely the same in any two genera—abound in the Miocene beds. There are traces of them in the Eocene, where a nearly allied group, the *Mimosas*, resembling them in the construction of their fruits (*legumes*, fig. 6) are not uncommon. Water-lilies covered the quiet surfaces of Swiss and English lakes during the Miocene period as they do in our own day. Cinnamon trees (now characteristic of the far East) abounded, Proteaceous plants (at present peculiar to the Southern Hemisphere) grew by their side, magnolias and tulip trees (well-known American forms) sprang up in botanical fellowship. In company with them were almond trees, plum trees, hawthorns, and many others familiar in temperate regions.

FIG. 6.

FOSSIL FRUIT (*Podogonium Knorrii*), UPPER MIOCENE, ŒNINGEN.
From a specimen in Ipswich Museum.

The Pliocene and Glacial periods witnessed the local extinction of many of the plants whose more generalized character enabled them to grow together during Miocene times, and the geographical distribution of others to the areas they now occupy. In a great measure the entomophilous flora has been otherwise specialized since then—many plants have become *monœcious* or *diœcious*, dimorphic and trimorphic, cleistogamous or otherwise aborted. These changes are still going on, and the appearance of man has done not a little to add to the disturbing agents in the floral equilibrium of the world. We have seen

that the appearance in geological time of the most beautiful or sweetly perfumed flowers is also that of the insects which now habitually frequent flowers. And as the wind-fertilized precede the insect-fertilized flowers in order of geological time, we contend that the latter may have been modified out of the former. Not unfrequently the same genus of plants contains both insect- and wind-fertilized flowers, as in our own common ash (*Fraxinus excelsior*) which is apetalous, and the species naturally abundant in the South of Europe, and now in our ornamental shrubberies, which possesses a corolla, and is therefore insect-fertilized (*F. ornus*). It is not to be concluded that the plants which bear the most beautiful flowers are the most highly organized, any more than such specially attractive insects as the Lepidoptera are also the highest in point of organization and development. Some of the Neuroptera, such as the white ants (*Termites*), and many among the Hymenoptera, as bees and ants, are more cerebrally developed. We have therefore a peculiar aspect of evolution here presented, not necessarily towards *higher* organization, as some people think is imperative in the new philosophy, but in the direction of special adaptation to each other's necessities and well-being on the part of two groups of organisms having no other connection with each other than that of having become mutually adapted to each other's requirements.

THE EXTINCT BRITISH WOLF.

By J. E. HARTING, F.L.S., F.Z.S.

THE interest which attaches to the history of extinct British animals can only be equalled by the regret which must be felt, by all true naturalists, at their disappearance beyond recall from our fauna. It seems almost incredible that the number of wild animals which have become extinct in the British Islands should equal, if it does not exceed, the number of the still existing forms with which we are familiar. And yet if we exclude from consideration the Chiroptera and the marine mammalia, this is not far from the truth.

Naming them at random, and commencing with the largest, the extinct British species are—the mammoth, elephant, rhinoceros (two, if not three species), hippopotamus, primæval ox, longfronted ox, aurochs, musk ox, Irish elk, reindeer, wild boar, brown bear, grizzly bear, great cave bear, lion, sabre-toothed lion, leopard or panther, hyæna, spotted hyæna, lynx, wolf, arctic fox, glutton, beaver, lemming, crane, and bustard. The *ferœ naturœ* still existing in Great Britain are—the red deer, the roe deer, fallow deer (introduced), wild white cattle, the hare, Alpine hare, rabbit, hedgehog, mole, shrew (three species), badger, otter, weasel, stoat, polecat, common marten, pine marten, wild cat, fox, squirrel, dormouse, harvest mouse, long-tailed field mouse, house mouse, black rat, brown rat, water vole, short-tailed vole, and bank vole.

One of the few wild animals which survived to within historic times, and hence one of the last to disappear, was the wolf, a creature whose ferocious and bloodthirsty nature caused it to be speedily singled out for extermination by the early English legislators.

To judge by the osteological remains which the researches of geologists have brought to light, there was perhaps scarcely a county in England or Wales in which, at one time or another, wolves did not abound, while in Scotland and Ireland they must have been even still more numerous.

The vast tracts of unreclaimed forest land which formerly

existed in these realms, the magnificent remnants of which in many parts still strike the beholder with awe and admiration, afforded for centuries an impenetrable retreat for these animals, from which it was well-nigh impossible to drive them. It was not, indeed, until all legitimate modes of hunting and trapping had proved in vain, until large prices set upon the heads of old and young had alike failed to compass their entire destruction, that by cutting down or burning whole tracts of the forests which harboured them, they were at length effectually extirpated.

In the course of the following remarks it is proposed to deal, first, with the geological evidence of the former existence and distribution of wolves in the British Islands; secondly, with the historical evidence of their survival and gradual extinction.

Under the latter head it will be convenient to arrange the evidence separately for England and Wales, Scotland, and Ireland: and, as regards England and Wales, to subdivide the subject chronologically into (1) the Ancient British period; (2) the Anglo-Saxon period; and (3) the period intervening between the Norman Conquest and the reign of Henry VII.

In this reign, it is believed, the last trace of the wolf in England disappeared, since history thereafter is silent on the subject. In Scotland and Ireland, however, this was by no means the case, as, later on, we shall have occasion to show.

Geological Evidence.

Owing to the great similarity which exists between the skeleton of a wolf and that of a large dog, it is sometimes extremely difficult for any but a good anatomist to distinguish between them. Professor Owen, in his "British Fossil Mammals," has remarked upon this difficulty, and has pointed out the chief distinguishing characters which may be relied upon for identification, and which lie chiefly in the skull.

So far as we have been enabled to collect the evidence, it would appear that undoubted remains of the wolf have been found in the following localities, for a knowledge of many of which we are indebted to Professor Boyd Dawkins' able paper, "On the Distribution of the British Post-Glacial Mammals," published in the *Quarterly Journal* of the Geological Society.*

Berkshire.—Windsor (Mus. Geol. Survey).

Derbyshire.—Pleasby Vale (Mus. Geol. Survey); Windy Knoll, Castleton (Dawkins, "Quart. Journ. Geol. Soc." xxxi. p. 246, and xxxiii. p. 727); Creswell Crag Caves (Mello and Busk, "Quart. Journ. Geol. Soc." xxxi. p. 684); Dawkins, *op. cit.* xxxii. p. 248, and xxxiii. pp. 590 and 602.

* *See* Vol. xxv. 1869, p. 192.

Devonshire.—Bench Cave, Brixham (W. A. Sanford); Kent's Hole, Torquay (Mus. Geol. Soc., Mus. Roy. Coll. Surg., and Mus. Oxford); Oreston, near Plymouth (Brit. Mus. and Mus. Geol. Soc.; Owen, "Brit. Foss. Mamm." p. 125).

Glamorganshire.—Gower, Bacon's Hole (Mus. Swansea; Falconer, "Palæont. Mem." ii. pp. 183, 325, 340, 349, 501); Bosco's Hole (Mus. Swansea; Falconer, tom. cit. pp. 510, 589); Crow Hole (Mus. Swansea; Falconer, tom. cit. p. 519); Deborah Den (Mus. Swansea; Falconer, tom. cit. p. 467); Long Hole (Falconer, tom. cit. pp. 400, 525, 538); Minchin Hole (Brit. Mus.; Mus. Swansea); Paviland (Mus. Oxford and Swansea; Owen, "Brit. Foss. Mamm." p. 124); Ravenscliff (Falconer, tom. cit. p. 519); Spritsail Tor ("Id." pp. 179, 462, 477, 522).

Gloucestershire.—Tewkesbury (Owen, "Brit. Foss. Mamm.").

Kent.—Murston, Sittingbourne (Mus. Geol. Survey).

Norfolk.—Denver Sluice* (Mus. Geol. Cambr.).

Oxfordshire.—Thame (Coll. Codrington, "Quart. Journ. Geol. Soc." xx. p. 374).

Somersetshire.—Benwell Cave (W. Borrer); Blendon (Mus. Taunton); Hutton (Mus. Taunton); Sandford Hill (Mus. Taunton); Uphill (Mus. Bath and Taunton); Wokey Hole (Mus. Oxford, Taunton, and Bristol).

Sussex.—Bracklesham (Brit. Mus. and Mus. Chichester); Pevensey† ("Sussex Archæol." Coll. xxiv. p. 160).

Wiltshire.—Vale of Kennet ("Sussex Archæol." tom. cit.).

Yorkshire.—Bielbecks (Mus. York; "Phil. Mag." vol. vi. p. 225); Kirkdale (Brit. Mus., Mus. Geol. Soc. and Roy. Coll. Surg.; Buckland, "Trans. Roy. Soc." 1822; Clift, *id.* 1823, p. 90).

We have here a dozen counties in different parts of England and Wales, north, south, east, and west, which show clearly from their position how very generally distributed the wolf must formerly have been.

The geological record, however, is but an imperfect one in showing the distribution of the wolf in bygone times, for to the localities above mentioned might be added numerous others in which we know from history that this animal formerly abounded. The forest of Riddlesdale in Northumberland; the great forests of Blackburnshire and Bowland in Lancashire; Richmond Forest, Yorkshire; Sherwood Forest, Nottinghamshire; Savernake Forest, Wilts; the New Forest; the forests of

* A landscape by R. W. Fraser "On the Ouze near Denver Sluice" was exhibited at the Royal Academy 1877, No. 794. The locality is a few miles to the South of Downham Market, and just below where the old and new Bedford rivers run into the natural stream.

† In 1851 many skulls of wolves were taken out of a disused mediæval well at Pevensey Castle.

Bere and Irwell, and many others are on record as former strongholds of these ferocious animals. To these we shall have occasion to refer later when dealing with the historical evidence.

Unlike other extinct British animals, the wolf apparently has not deteriorated in size, for the fossil bones which have been discovered, as above mentioned, are not larger, nor in any way to be distinguished from those of European wolves of the present day.

Historical Evidence—England.

Ancient British Period.—Dio Nicæus, an ancient author, speaking of the inhabitants of the northern parts of this island, tells us they were a fierce and barbarous people, who tilled no ground, but lived upon the depredations they committed in the southern districts or upon the food they procured by hunting. Strabo also says (lib. iv.) that the dogs bred in Britain were highly esteemed upon the Continent on account of their excellent qualities for hunting, and these qualities, he seems to hint, were natural to them, and not the effect of tutorage by their foreign masters. Hunting the wolf appears to have been a favourite pursuit with these ancient Britons. Mempricius, who is supposed to have reigned B.C. 980, fell a victim in that year to the wolves which he delighted to pursue, and was unfortunately devoured by them. Blaiddyd, another British monarch (B.C. 863), who seems to have been learned in chemistry, is said to have discovered the medicinal properties of the Bath mineral waters, by observing that cattle when attacked and wounded by the wolves went and stood in these waters, and were then healed much sooner than they would have been by any other means.* From this it may be inferred that wolf-hunting was found by the ancient Britons to be a necessary and pleasurable, yet dangerous, pursuit.

We do not find, says Strutt,† that during the establishment of the Romans in Britain, there were any restrictive laws promulgated respecting the killing of game. It appears to have been an established maxim in the early jurisprudence of that people, to invest the right of such things as had no master with those who were the first possessors. Wild beasts, birds, and fishes became the property of those who first could take them. It is

* For this note we are indebted to Mr. John Hoare, who is at present engaged on a most interesting work called "Annals of the Chase in the British Islands," and who has kindly favoured us with a sight of such portions of his MSS. as relate to the wolf.

nd Pastimes of the People of England."

most probable that the Britons were left at liberty to exercise their ancient privileges; for had any severity been exerted to prevent the destruction of game, such laws would hardly have been passed over without the slightest notice being taken of them by the ancient historians.

Anglo-Saxon Period.—As early as the ninth century, and doubtless long before that, a knowledge of hunting formed an essential part of the education of a young nobleman. Asser, in his life of Alfred the Great, assures us that that monarch before he was twelve years of age "was a most expert and active hunter, and excelled in all the branches of that most noble art, to which he applied with incessant labour and amazing success." Hunting the wolf, the wild boar, the fox, and the deer, were the favourite pastimes of the nobility of that day, and the dogs which they employed for these various branches of the sport, were held by them in the highest estimation.

Such ravages did the wolves commit during winter, particularly in January when the cold was severest, that the Saxons distinguished that month by the name of "wolf month."

"The month which we now call January," says Verstegan, "they called 'Wolf monat,' to wit 'Wolf moneth,' because people are wont always in that month to be in more danger to be devoured of wolves than in any season else of the year; for that, through the extremity of cold and snow, these ravenous creatures could not find of other beasts sufficient to feed upon."*

The Saxons also called an outlaw "wolfs-head,"† as being out of the protection of the law, proscribed, and as liable to be killed as that destructive beast. "*Et tunc gerunt caput lupinum, ita quod sine judiciali inquisitione rite pereant.*"‡

It is to the terror which the wolf inspired among our forefathers that we are to ascribe the fact of kings and rulers, in a barbarous age, feeling proud of bearing the name of this animal as an attribute of courage and ferocity. Brute power was then considered the highest distinction of man, and the sentiment was not mitigated by those refinements of modern life which conceal but do not destroy it. We thus find, amongst our Anglo-Saxon kings and great men, such names as Ethelwulf, "the noble wolf;" Berthwulf, "the illustrious wolf;" Eadwulf, "the prosperous wolf;" Ealdwulf, "the old wolf."§

* "Restitution of Decayed Intelligence," p. 64 (ed. 1673).

† Ang. Sax. *Wulvesheofod*, that is, having the head of a wolf. The term was in use temp. Henry II.

‡ Bracton, "De legibus et consuetudinibus Angliæ," lib. iii. tr. ii. c. 11 (1569). *See* also Knighton, "De Eventibus Angliæ," in Twysden's "Historiæ Anglicanæ Scriptores Decem," p. 2356 (1652).

§ Wulfere, King of Mercia (A.D. 660), had a son Wulfade.

In Athelstan's reign, wolves abounded so in Yorkshire that a retreat was built by one Acehorn, at Flixton, near Filey, in that county, wherein travellers might seek refuge if attacked by them.

Camden says:—"More inward stands Flixton, where a hospital was built in the time of Athelstan, for defending travellers from wolves (as it is word for word in the public records) that they should not be devoured by them."* When Athelstan, in 938, obtained a signal victory at Brunanburgh over Constantine, King of Wales, he imposed upon him a yearly tribute of gold, silver and cattle, to which was also added a certain number of "hawks and sharp-scented dogs, fit for the hunting of wild beasts."† His successor, Edgar, remitted the pecuniary payment on condition of receiving annually from Ludwall ‡ (or Idwal §), the successor of Constantine, the skins of three hundred wolves.|| We do not find, indeed, that the hawks and hounds were included in this new stipulation, but it does not seem reasonable that Edgar, who, like his predecessor, was extremely fond of field sports, should have remitted that part of the tribute.¶

It is generally admitted that Edgar relinquished the fine of gold and silver imposed by his uncle Athelstan upon Constantine, and claimed in its stead the annual production of 300 wolf-skins, because, say the historians, the extensive woodlands and coverts, abounding at that time in Britain, afforded shelter for the wolves, which were exceedingly numerous, and especially in the districts bordering upon Wales. By this prudent expedient, in less than four years, it is said, the whole island was cleared from these ferocious animals, without putting his subjects to the least expense.** But, as Strutt has observed,†† "if this record be taken in its full latitude, and the supposition established, that the wolves were totally exterminated in Britain during the reign of Edgar, more will certainly be admitted than is consistent with the truth, as certain documents clearly prove." The words of William of Malmsbury

* Camden, "Britannia," tit. Yorkshire, vol. ii. p. 902 (2nd ed.).

† William of Malmsbury, "Hist. Reg. Anglorum," lib. ii. c. 6.

‡ *Cf.* Holinshed's "Chronicles," Vol. i. p. 378 (4to. ed. 1807).

§ *Cf.* Camden's "Britannia," tit. Merionethshire, tom. ii. p. 785.

|| William of Malmsbury, op. cit. lib. ii. c. 8.

¶ Strutt, "Sports and Pastimes of the People of England."

** It is singular that the same expedient has been resorted to in modern times, and with considerable success. In the accounts of Assinniboia, Red River Territory, there is an entry of payment for wolves' heads; and in 1868 the State of Minnesota paid for wolves' scalps 11,300 dollars, at the rate of 10 dollars apiece.

†† "Sports and Pastimes of the English People."

on the subject are to this effect, that "he, Edgar, imposed a tribute upon the King of Wales, exacting yearly 300 wolves. This tribute continued to be paid for three years, but ceased upon the fourth, because '*nullum se ulterius posse invenire professus*,' 'it was said that he could not find any more.'" *

> "Cambria's proud Kings though with reluctance paid
> Their tributary wolves, head after head,
> In full account, till the woods yield no more,
> And all the ravenous race extinct is lost."

But this must be taken to refer only to Wales, for in the first place it can hardly be supposed that the Welsh chieftain would be permitted to hunt out of his own dominions, and in the next place there is abundant documentary evidence to prove the existence of wolves in England for many centuries later.

Holinshed, who gives a much fuller account, says:†—"The happie and fortunate want of these beasts in England is vniuersallie ascribed to the politike gouernment of King Edgar, who to the intent the whole countrie might once be clensed and clearelie rid of them, charged the conquered Welshmen (who were then pestered with these rauenous creatnres aboue measure) to paie him a yearlie tribute of woolfes skinnes, to be gathered within the land. He appointed them thereto a certaine number of 300, with free libertie for their prince to hunt and pursue them ouer all quarters of the realme; as our chronicles doo report. Some there be which write how Ludwall, prince of Wales, paid yearelie to King Edgar this tribute of 300 woolfes, whose carcases being brought into Lloegres, were buried at Wolfpit, in Cambridgeshire, and that by meanes thereof within the compasse and terme of foure yeares, none of these noisome creatures were left to be heard of within Wales and England. Since this time, also, we read not that anie woolfe hath beene seene here that hath beene bred within the bounds and limits of our countrie: howbeit there haue beene diuerse brought over from beyond the seas for greedinesse of gaine, and to make monie onlie by the gasing and gaping of our people vpon them, who couet oft to see them, being strange beasts in their eies, and sildome knowne (as I haue said) in England."

The learned Dr. Kay‡ acquiesced in the vulgar opinion of

* "Hist. Reg. Anglorum," lib. ii. cap. 8. *See* also Wynne's "Caradoc," p. 51.

† "Chronicles of Engl., Scot., and Irel." (ed. 4to. 1807), Vol. i. p. 378, bk. iii. chap. iv. "Of Savage Beasts and Vermines."

‡ "Joannis Caii Britanni 'de Canibus Britannicis' Liber unus. De rariorum animalium et stirpium Historia." Londini, per Gulielmum

the extinction of wolves in England by King Edgar, and in his work on British Dogs, published in 1570, treating of the sheep-dog 'Pastoralis,' he says: "Sunt qui scribunt Ludwallum Cambriæ principem pendisse annuatim Edgaro regi 300 luporum tributi nomine, atque ita annis quatuor omnem Cambriam, atque adeo omnem Angliam, orbasse lupis.

"Regnavit autem Edgarus circiter annum 959. Quamobrem non legimus nativum in Anglia visum lupum."

The worthy doctor seems to have been little aware that even at the date at which he wrote wolves still existed in the British Islands. Pennant, referring to the received opinion that a great part of the kingdom was freed from wolves through the exertions of King Edgar, says:—"In England he attempted to effect it by commuting the punishments for certain crimes into the acceptance of a number of wolves' tongues from each criminal; in Wales by converting a tax of gold and silver into an annual tribute of 300 wolves' heads. Notwithstanding his endeavours, however, and the assertions of some authors to the contrary, his scheme proved abortive."*

We have lately met with a statement to the effect that "two wooden wolves' heads still remain near Glastonbury on an ancient house where [query, on the site of which] at Eadgerly, King Eadger lived and received annually his tax from the Welsh in 300 heads."†

This statement, however, conflicts somewhat with that of Holinshed, who says that "the carcases being brought into Loegres, were buried at Wolfpit in Cambridgeshire."‡

In the Forest Laws of Canute, promulgated in 1016, the wolf is thus expressly mentioned:—"As for foxes and wolves, they are neither reckoned as beasts of the forest or of venery, and therefore whoever kills any of them is out of all danger of forfeiture, or making any recompense or amends for the same. Nevertheless, the killing them within the limits of the forest is a breach of the royal chase, and therefore the offender shall yield a recompense for the same, though it be but easy and gentle."§

It was doubtless to this constitution that the Solicitor-General St. John referred, at the trial of the Earl of Strafford, when he said, "We give law to hares and deer, because they are beasts

Seresium. 8vo. 1570. There is a translation of this work in the British Museum, entitled, "Of Englishe Dogges, newly drawn into English." By Abraham Fleming, Student. London. 4to. 1576.

* "British Zoology," Vol. i. p. 88 (1812).

† "Sussex Archæol. Coll." Vol. iv. p. 83 (1851).

‡ "Chronicles," Vol. i. p. 378 (4to. ed. 1807).

§ *See* Manwood's "Forest Laws." The Charter of the Forest of Canutus the Dane (§ 27).

se; but we give no law to wolves and foxes, because they
asts of prey, but knock them on the head wherever we
em."*
lphus, a dean of Whalley in the time of Canute, was
ıted as a wolf-hunter at Rossendale, Lancashire." †
thew Paris, in his "Lives of the Abbots of St. Albans,"
ns a grant of church lands by Abbot Leofstan (the 12th
of that monastery) to Thurnoth and others, in consider-
ıf their keeping the woods between the Chiltern Hundreds
ondon free from wolves and other wild beasts.
ould seem that the "ancient and accustomed tribute"
the English kings was repeated by the Welsh princes in
ry last years of the Anglo-Saxon monarchy. It was
ded by and rendered to Harold.

* Clarendon, "Hist. Reb." fol. ed. i. p. 183.
† Whitaker's "History of Whalley," p. 222.

(To be continued.)

ON THE INTERPRETATION OF SOME EXPERIMENTS RELATING TO THE INDUCTIVE EFFECT PRODUCED BY THE ROTATION OF A MAGNET ON ITS AXIS.

By S. TOLVER PRESTON.

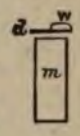
1. A curious and interesting question is raised by some experiments of Faraday, described in the "Philosophical Transactions," in regard to the inductive effect attendant on the rotation of a magnet on its axis. Faraday appears to have considered that experimental results rendered it necessary to draw a distinction between the motion of *rotation* and the motion of *translation* of a magnet, in regard to the behaviour of the system of force about it; for he says ("Phil. Trans." 1852, p. 31), "When lines of force are spoken of as crossing a conducting circuit, it must be considered as effected by the translation of a magnet. No mere rotation of a bar magnet on its axis produces any inductive effect on circuits exterior to it. The system of power about the magnet must not be considered as revolving with the magnet, any more than the rays of light which emanate from the sun are supposed to revolve with the sun. The magnet may even in certain cases be considered as revolving amongst its own forces, and producing a full electric effect sensible at the galvanometer."

2. At the first sight it will appear theoretically a strange conclusion (and Faraday himself designates it afterwards as "singular") that the above distinction between a motion of rotation and a motion of translation should hold. For even if we take the above illustrative case of the sun, it must appear evident (as regards the light emitted from any luminous portion of the sun) that any effect that was produced by the translation of that luminous portion through space would equally be produced by the rotation of that same portion about the axis of the sun, for rotation *is* simply *translation in a circle*. So by the rotation of a magnet on its axis, its constituent parts are *translated* in circles. It would therefore seem necessarily to follow theoretically that any law that applied to the translation of a magnet would equally apply to its rotation. It is an observed fact that by the *translation* of a magnet, the inductive effect produced on

external conductors is precisely the same as if these conductors were themselves translated with the same relative velocity past the stationary magnet, or the effect simply depends on *relative* motion. It would therefore seem a necessary inference that the effect by the rotation of a magnet also depended on *relative* motion, or that the inductive effect on any external conductor would be the same whether the conductor were moved past the periphery of the magnet, or the periphery of the magnet were (conversely) moved with the same relative velocity past the conductor (by the rotation of the magnet on its axis).

3. Faraday, however, appears to have considered that experimental results opposed this inference, for he concluded (as stated in the above quotation) that while the rotation of the conductor about the magnet produced an inductive effect on the conductor, the same relative motion of the magnet to the conductor (when the magnet rotates on its axis) produced no inductive effect on the conductor. The experiment on which this conclusion was grounded was as follows ("Phil. Trans." 1832, p. 183):—A circular disk of copper *d* (fig. 1) was rotated on its axis above the pole of a cylindrical bar magnet *m*. A wire *w* (in whose circuit a galvanometer—not shown—was placed) had one end maintained in sliding contact with the edge of the disk, and the other with the centre of the disk. It was found that the current given off by the rotation of the disk, and passing through the wire *w*, was precisely the same whether the magnet *in addition* was rotated on its axis in either direction, or remained stationary. Hence it was concluded that the rotation of the magnet on its axis produced no inductive effect on the disk, or (generally) that a rotating magnet could produce "no inductive effect on conductors exterior to it." Faraday adds, after a second perfectly similar experiment to the above with a cylindrical copper can instead of a disk (p. 184)—"Thus a singular independence of the magnetism and the bar in which it resides is rendered evident." In other words, it was inferred that the system of force about the magnet could not be regarded as partaking of the motion of the magnet and crossing external conductors, when the magnet rotated on its axis. It will be observed that this necessarily involves the conclusion that, although the system of force emanating from the periphery of a magnet *admittedly* shares the motion (so as to cross external conductors) when the periphery is moved in the act of *translation* of the magnet, yet that it does not do so when the periphery is moved in the act of rotation of the magnet on its axis. It is difficult to see how this conclusion could be theoretically consistent, for what distinction can be logically drawn between a motion of rotation and one of translation in this case, as by the rotation of a mag-

Fig. 1.



net on its axis its periphery is *translated* in a curve, and evidently a different law could not apply to the behaviour of the system of force according as to whether it is translated in a curved or in a straight line. We should have considerable diffidence in criticizing anything put forward by so eminent an authority, but scientific truth is admittedly paramount, and no one would claim immunity from an oversight. We think it may be distinctly shown that the above is an oversight resting upon the rather curious accident that the particular experiment tried admits of a *double* interpretation.

4. Thus if we make no distinction between the behaviour of the system of force whether the magnet is translated or rotated, or assume that the system of force about the magnet is invariably at rest *relatively to the magnet*, then by the rotation of the magnet on its axis the system of force accompanying the magnet will cross *both* the wire *w* and the disk *d*, thereby tending to generate a current in them both in opposite directions—so that there will be no actual current at all. This is therefore why the magnet when rotated in either direction produces no difference in the results. The final result is the same, not because the rotating magnet produces no inductive effect, but because the inductive effects upon the wire and disk *oppose* each other; or the rotating magnet causes an electric disturbance both in the disk and in the external wire in such a way as to produce a balanced static charge, so that no current is possible. To prove that the inductive effects in the disk and wire exactly balance each other, it is only necessary to rotate the disk and wire together through the lines of force of the stationary magnet, when there will be (as is known) no current in the circuit made up of the disk and wire, the effects in the disk and wire therefore exactly opposing each other. So therefore it becomes clear how the rotation of the magnet on its axis can make no difference in the results; and therefore the experimental result does not warrant the above singular distinction drawn in regard to the behaviour of the system of force when a magnet rotates on its axis. This distinction would indeed involve the conclusion that there is no inductive effect on the disk when the magnet rotates below the disk, but that there is an inductive effect when the disk rotates above the magnet, *i.e.* that the effect is different when the *relative* motion of the disk and magnet is the same, or in other words, that the inductive effect would depend on *absolute* and not on *relative* motion. This is negatived by the behaviour of the helix, whose inductive influence depends (as is known) on *relative* motion; and the same with electrodynamic phenomena generally. It would therefore be strange that the magnet when rotated on its axis should form an exception to the general law, and we think that after it has been shown that the

above experiment admits of just interpretation consistent with the fact that the inductive effect depends on *relative* motion, no one will doubt that this is really the case. However, the point may be independently proved from other considerations.

I. In experiments bearing on this question ("Phil.Trans." 1852, p. 30), a compound magnet was used, consisting of two rectangular bar magnets placed side by side with a slight interval between them (as shown in cross section, fig. 2). The two magnets were rotated about a common axis x. Now if we take a purely theoretic view of this question, and suppose one bar to be removed, then it will be evident that by the rotation of the other about the axis x (now external), the centre of gravity of the bar will be *translated* about that axis, in which case it is *admitted* that the lines of force partake of the motion of the bar and would intersect any external conductor, producing an inductive effect on it. Let now the other magnet be added, and the same holds true of it, *i.e.* its lines of force partake of its motion and intersect any external conductor; and we therefore have now the entire compound bar rotating on its axis, and its lines of force partaking of its motion and intersecting external conductors. This must be sufficiently clear, and if we discuss the matter further, it is with the view rather to consider some facts possessing a certain novelty in their aspects than to add proof to the above conclusion.

Fig. 2.

II. Let us suppose one of the above magnets (fig. 2) to be again removed, and the remaining one to be made to revolve about the external axis x, a copper disk being placed concentrically above this axis. Then by the excentric rotation of the magnet about the external axis x, the centre of gravity of the magnet is *translated* past the disk, so that the lines of force of the magnet intersect the disk and generate currents in it, which discharge themselves in the portion of the disk remote from the pole of the magnet. But if the second magnet be now added, the disk will then (by the rotation of the compound magnet) be continuously and symmetrically covered by the pole of the compound magnet, so that the currents have nowhere to discharge themselves. There is therefore no effect of a current in the disk observed. This is, however, no proof of absence of inductive effect on the part of the rotating magnet; but from the very fact that the currents tend to be generated equally along all the radii of the disk, no back flow is possible, but the centre and circumference of the disk are simply charged up with electricity of opposite sign. If a wire be made to connect the centre and circumference of the disk, the accumulated electricity cannot discharge itself through the wire, because *the wire itself is acted on* by the rotating magnet in the same way as the disk, and no discharge is possible. The disk in this case is charged in pre-

cisely the same way as it would be if (conversely) *it* rotated and the magnet were at rest, or the effect depends simply on *relative*, not on *absolute* motion.

III. The consideration of action and reaction also proves the same point. If a copper disk be oscillated about its own centre (*i.e.* be made to rotate in alternate directions about its centre) above and parallel to the flat surface of the pole of a magnet, and concentric with the magnet's axis, radial currents will (as is known) be generated in alternate directions in the disk at each alternate oscillation of the disk, *i.e.* the disk will be charged at its centre and circumference alternately positively and negatively. This alternate flow of electricity between the centre and circumference of the disk will tend to damp the oscillations of the disk, or to bring it to rest. Now on the principle that action and reaction are equal and contrary, the action between the magnet and disk must be *mutual*, and therefore the magnet, if freely suspended, would tend to be thrown into oscillation (about its axis) by the oscillations of the disk; or if the magnet were (conversely) itself artificially put in oscillation, the magnet would tend to put the disk in oscillation. But the magnet could not do this unless, by its rotation on its axis, *it produced an inductive effect on the disk.* The principle of action and reaction therefore affords additional confirmation of the fact that the rotating magnet has an inductive effect on the disk.

IV. Let NS (fig. 3) represent a spherical magnet suspended so as to rotate freely inside a metallic ring (a slight interval existing between the ring and the magnet), the axis of rotation of the magnet being *perpendicular* to the magnetic axis NS. Then it is an accepted fact that a current (indicated by the arrows) will flow round the ring by the rotation of the magnet, the direction of the current reversing itself at each semi-revolution. The lines of force of the rotating magnet therefore intersect the ring, precisely as they would do if (conversely) the magnet were at rest and the ring rotated through the lines of force of the magnet. If now the magnet be rotated about its *magnetic axis* NS (fig. 4), currents will also be generated, charging up the ring statically in the manner indicated in the figure, the sign of the electricity being opposite at the polar and equatorial parts of the ring (the charge being permanent so long as the magnet rotates). If the existence of this inductive effect be not admitted, then it would be necessary to conclude that the lines of force emanating from the magnet, intersect the ring when the magnet is rotated about one axis (fig. 3), but not so when the magnet

Fig. 3.

Fig. 4.

is rotated about another axis (fig. 4); *i.e.* that the system of force about the magnet obeys one law when the magnet is rotated about one axis, but a different law when it is rotated about an axis perpendicular to the former; which is evidently quite untenable. Indeed it must be perfectly clear that we have here simply a case of *relative* motion, or the inductive effect is the same as if (conversely) the ring were made to rotate about the fixed magnet, when, as a *known fact*, the ring would be charged up in the manner indicated. To assume that a magnet when rotating on its axis produces no inductive effect, would be to assume that when the magnet rotates inside the ring, there is no effect on the ring, but when (conversely) the ring rotates about the magnet, there is an effect on the ring, *i.e.* that the result is *different* while the *relative* motion is the *same*, or that the result depends on the *absolute* motion of the ring. Now it is an admitted characteristic of electro-dynamic phenomena to depend on *relative* and not on *absolute* motion. Moreover, to suppose that it made no difference whether the magnet was rotated or not, would involve the assumption that when magnet and ring rotate *together* with the same velocity, and therefore there is relative *rest*, the effect is the same as when the ring only rotates, or there is relative *motion*. These are therefore some of the inconsistent conclusions to which the above hypothesis necessarily leads, and which thereby prove the hypothesis to be untenable.

V. From the hypothesis that the system of force of a rotating magnet does not partake of the motion of the magnet, it followed as a necessary conclusion that when a magnet rotated on its axis, it revolved through *its own system of force*, producing an inductive effect on itself, charging itself statically at the polar and equatorial parts with electricity of opposite sign. Thus the earth being a magnet, it was considered that the polar and equatorial parts of the earth must be charged up with electricity of opposite sign, by its rotation on its axis, and the surmise was thrown out (merely as a dependent suggestion) that the electric phenomenon of the Aurora Borealis might have some connection with this ("Phil. Trans." 1832, p. 177). The same conclusion was also arrived at by M. Plücker and published in "Poggendorff's Annalen" (1852, p. 357) in a paper—"Ueber die Reciprocität der elektromagnetischen und magnetoelektrischen Erscheinungen." M. Plücker describes a number of experiments with currents in support of his view that a magnet charges itself up by its own rotation; but since all his experiments in *principle* resemble the first one described (with the rotating disk), and since he has overlooked precisely the same fact as that pointed out (the same oversight affecting all his experiments alike), it will be unnecessary to refer to these experiments here.

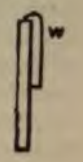
Since we have shown that no distinction can logically be drawn between a motion of rotation and one of translation in regard to the behaviour of the lines of force about a magnet, but that the lines of force must be regarded as accompanying the magnet *whatever* the nature of its motion (*i.e.* the system of force must be regarded as at rest *relatively to the magnet*), so therefore no static charge can ensue by the rotation of the earth on its axis; the system of force about the earth being *relatively to it at rest*. There may be one point that may be worth noticing here. The tides form two elevated protuberances of water which do *not* partake of the earth's rotation, and therefore virtually rotate through the lines of force of the earth. For our purpose the tide may be regarded simply as a stationary ring or belt of water, within which the earth rotates. The inductive effect being dependent on *relative* motion (not on *absolute* motion), the same inductive effect is therefore produced upon the belt of water as if the earth were at rest and the belt of water revolved with the same relative velocity round the earth. It follows therefore that this belt of water will be inductively influenced in such a way that the parts of it lying near the equator are charged up with electricity of opposite sign to the parts lying near the poles. This may therefore constitute a true cause for a disturbance of the electric equilibrium, and which would not exist if it were not for the tides.

VI. As a final illustration of the truth of the point contended for, it may be observed that it is an accepted fact that the magnet and the helix are perfectly analogous in their fundamental properties. Now it is well known that the inductive influence of currents upon each other depends on *relative*, not on *absolute* motion. So then when a helix (or simply a single circular current) rotates on its axis, the rotating helix produces (admittedly) upon external conductors an inductive effect, precisely the same as would be produced if the helix were at rest and the conductors were (conversely) made to revolve with the same relative velocity about the helix, or it is only a question of *relative* motion. So therefore (by analogy), when a magnet rotates on its axis, it produces the same inductive effect on external conductors, as if these conductors were themselves caused (conversely) to revolve with the same relative velocity about the stationary magnet, or it is here also only a question of *relative* motion.

5. This method of viewing the case serves to simplify the phenomena of Electro-magnetic Rotation by correlating them under *one* cause, instead of regarding the mode of action as different in the two cases, first, when the magnet *rotates on its axis*, and, second, when, conversely, the portion of the *circuit rotates* about the magnet. Thus to take the example

fig. 5, which represents in its simplest form the well-known apparatus for generating an electric current from the relative motion of a magnet and a portion of a circuit; or (conversely) for developing a movement of rotation by means of a current introduced into the circuit. It consists simply of a magnet and a wire, w, the wire being so arranged as to be capable of rotating about the magnet, with its ends maintained (by convenient means) in slipping contact with the polar and equatorial parts of the magnet. By this arrangement of the wire, whatever its shape or length, it cuts (as is known) by one revolution all the lines of force of the magnet. Here a current may be generated either by rotating the wire about the magnet, or by rotating the magnet on its axis, in both which cases the *relative motion of the wire and magnet is the same*, and therefore the cause of the current the same. It was here supposed, however, in accordance with the hypothesis adopted, that the cause of the current was *different* in the two cases. When the wire rotated about the magnet, it was admitted that the current was due to the intersection of the external lines of force of the magnet by the wire. When, however, the magnet rotated on its axis, the current was supposed to be due to a different cause. It was here supposed (according to the hypothesis adopted) that the rotating magnet intersected its own system of force, becoming charged up statically at the polar and equatorial parts, and that the wire, w, led off this charge—that *this*, therefore, was the cause of the current in the wire w. This, therefore, it may be observed, makes a difference in the mode of action in two cases where the *relative* motion is the same. This, however, need not be done, for regarding the system of force about the magnet as accompanying the magnet *whatever* the nature of its motion (*i.e.* the system of force as invariably at rest *relatively to the magnet*), it follows that when the magnet rotates on its axis, its system of force accompanies it and intersects the wire w, thereby generating a current in the wire, precisely as it did when (conversely) the wire, w, was made to intersect the system of force (by the rotation of the wire about the magnet). Thus the effects in both cases become correlated under *one* cause, viz., the *relative* motion of the wire w, and the system of force of the magnet. The singular distinction drawn when the magnet rotates on its axis is therefore shown not to be necessitated by the experimental facts.

Fig. 5.



6. Taking now the reverse case, when the current of a battery is applied either to cause the external wire, w, to rotate about the magnet, or to make the magnet rotate on its axis, the battery current being made to traverse the circuit made up of the magnet and external wire, w. Here, also, evidently the same con-

siderations must apply, or there is no necessity to draw a distinction in the mode of action in the two cases when the magnet rotates (on its axis), and when the wire rotates about the magnet, but the effect is simply one of relative motion. When a current is transmitted through the circuit; the wire, w, reacts upon the system of force of the magnet, and both the magnet and the wire thereby tend to be propelled in opposite directions (or the action is *mutual*). Whether therefore the magnet rotates (on its axis) or the wire rotates about the magnet, merely depends on which is free to move, and therefore the rotation is due to the *same* cause in both cases, *i.e.* to the *mutual* reaction between the wire, w (traversed by a current), and the external lines of force of the magnet. On the other hand, the hypothesis that a rotating magnet and its system of force were *independent* of each other, necessarily would involve the assumption that there can be no reaction between the external wire and the magnet, which leaves us the only remaining conclusion that the magnet is caused to rotate *by the portion of the current within itself*. Here we encounter the difficulty of a current within a body causing the rotation of that body without any external object for the current to react upon. This difficulty disappears at once on the view (already enunciated) that the rotation of the magnet on its axis is due to the reaction between it and the *external* wire, or to the same cause as the rotation of the wire (conversely) about the magnet. This view also brings the properties of the magnet into agreement with those of the helix (as in accordance with Ampère's theory); for it is well known that the rotation of a helix on its axis is solely due to the reaction of the *external* portion of the circuit upon the helix.

7. In connection with this subject, the following experiment was made ("Phil. Trans." 1852, p. 33). A magnet had a portion of wire rigidly attached to it in the form of a loop (as in fig. 5), and magnet and wire were rotated together, when no current was found to exist in the circuit made up of the magnet and wire. This result was accounted for as follows, on the same hypothesis. When the magnet and attached wire rotated together as a whole, the magnet was supposed to rotate through its own system of force, thereby becoming charged up statically; the wire was supposed to rotate through the external system of force of the magnet (the wire also becoming charged up statically), the magnet and the wire thus tending to generate a current in opposite directions, so that this was assumed to be the cause why no actual current was produced. The observed result may however be simply explained on the consideration that, when the magnet and wire are rotated *together*, and rigidly attached, the two are *relatively* at rest, and therefore no induc-

tive effect is produced; not therefore that two disturbances of the electric equilibrium exist in the wire and magnet, and oppose each other, but that no inductive effect at all is produced (there being no relative motion). In this respect also the magnet and the helix agree. For it is well known in the case of a helix traversed by a current, if a conductor of any shape be rigidly fastened to the helix and rotated with it, no inductive effect whatever will be produced, simply because the two are relatively at rest. It may be observed that it is here the case of one and the same hypothesis affecting all the results we have considered, for as soon as it was believed that the experimental results necessitated the above hypothesis, it necessarily (to be consistent) influenced the theoretic deductions throughout. The hypothesis arose, as is sufficiently evident, from a simple oversight, or from not observing the rather curious fact that the experiment, on which it was based, admitted of a *double* interpretation.

8. To summarize the conclusions therefore:—

I. When a magnet rotates on its axis, it produces an inductive effect on bodies external to it. This inductive effect is the same as if the external bodies were themselves (conversely) caused to revolve with the same relative velocity about the fixed magnet. The action of the helix agrees with that of the magnet in this respect (*i.e.* in the effect being dependent on *relative* motion).

II. A rotating magnet does *not* produce an inductive effect on *itself*, *i.e.* does not become statically charged. The system of force about the magnet must be considered as at rest *relatively to the magnet*, and this holds true *whatever* the nature of the motion of the magnet (whether rotatory or translatory). The system of force about the earth (as a rotating magnet) must therefore be considered as at rest *relatively to the earth*, so that the earth cannot become statically charged at the poles by its rotation. On the other hand in the case of the tides, when there is relative motion (in regard to the earth), an electric disturbance may thus be brought about.

III. The inductive effect produced by the movements of magnets and external conductors depends solely on *relative* and not on *absolute* motion, and this holds true independently of the *nature* of the motion of the magnet (whether rotatory or translatory). In this the helix agrees with the magnet, inasmuch as the inductive effect produced by a helix depends on the relative motion of it to external conductors, and no exception has to be made to this, whether the motion of the helix be rotatory or translatory.

IV. So then, when a magnet and an external conductor *rigidly* attached to it are rotated together with whatever

absolute velocity, there is no inductive effect, because the two are *relatively* at rest. It follows therefore that in such a case the two are not charged up statically by the rotation in such a way as to tend to produce currents in opposite directions, but no effect at all is produced.

V. In the apparatus for producing Electromagnetic Rotation, the effect depends merely on the *relative* motion of the magnet and the external portion of the circuit, and the case when the magnet rotates on its axis makes no exception to this law. When the magnet rotates on its axis, or when (conversely) the external portion of the circuit rotates about the magnet, the mode in which the effect is brought about is the *same*, and is dependent on *relative* motion.

9. All the conclusions above summarized apply admittedly to the helix, and therefore to demonstrate them to apply to the magnet is only to reconcile completely two cases where the fundamental properties have been generally considered as identical; but which however could not be reconciled with each other, unless the above supposed distinction when a magnet rotates on its axis could be explained away.

10. Of course on the adoption of Ampère's theory of magnetism, all the conclusions above summarized necessarily apply to the magnet, since this theory was propounded on a recognition of the identity of the properties of the magnet and helix, founded upon observation. Faraday, who apparently considered that experiment compelled the adoption of the above exceptional hypothesis in the case where a magnet rotates on its axis, and which he himself designates as "singular" (opposing as it does the generalization of the properties of the magnet with those of the helix)—would no doubt have been ready to abandon the hypothesis, had he observed that such a course would be consistent with a just interpretation of the experimental results.

REVIEWS.

BRITISH BARROWS.*

THIS excellent work contains a full account of the examination of more than two hundred and thirty sepulchral mounds, belonging to some period before the occupation of Britain by the Romans. The barrows, examined by Canon Greenwell himself, were principally (123) on the Wolds of the East Riding of Yorkshire; but some were in the North (37) and West (2) Ridings, two in Cumberland, several in Westmoreland (19) and Northumberland (31); one in Durham, and five in Gloucestershire. In preliminary observations on each district in which these mortuary mounds occur, the author has given some account of the natural characters of the soil, and of discoveries made by other explorers. An elaborate table, occupying pages 458-478, shows the localities of these barrows, the nature of the interments in them, whether primary or secondary, placed in a grave or not, and burnt or unburnt; also the position of body, and the nature and material of the weapons, implements, vessels, pins, buttons, and ornaments, deposited with the interments.

The description of fourteen *Long Barrows*, opened by the author in Yorkshire, Westmoreland, and Gloucestershire, follows; with special treatment of the characters and probable history of these peculiar sepulchres.

Based on the varied and accurate knowledge of details obtained in this careful opening of tumuli, and enlarged by extensive reading, and by friendly intimacy with antiquaries at home and abroad, an Introduction, comprising what is known about these and other mounds, precedes the descriptive record of the excavations. Of the many interesting subjects treated of in this résumé of what is known of the old Flint-folk and Bronze-people of Yorkshire, the following are first discussed:—the form and material of the barrows, the stone circles enclosing them, the circular holes in their floors, the flint flakes and potsherds so abundantly mixed with their heaps,—the manner of burial of the corpse on the ground, in hollows, or in cists,—of burnt bodies in urns or otherwise,—successive burials in the same barrow,—

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* "British Barrows: A Record of the Examination of Sepulchral Mounds in various parts of England, by William Greenwell, M.A., F.S.A. Together with descriptions and figures of skulls, general remarks on Prehistoric Crania, and an appendix, by George Rolleston, M.D., F.R.S." 8vo. "Clarendon Press," Oxford, 1877. With numerous wood engravings.

the position of the body (usually on the side and contracted with knees and hands near the chin), and the direction of the head.

The occurrence of charcoal in graves with apparently unburnt bodies is accounted for by the supposition that the idea of the necessity of burning, as a rite, or the passing the body through fire, the Purifier, survived the practice of actual and perfect cremation, just as *aspersion* takes the place of complete *immersion* in some forms of baptism.

Traces of personal dress in the burials are rare, but sufficient to render it probable that the body was interred in its clothes or in some kind of shroud. Remains of woollen and leathern garments have been met with; but more frequently there are dress-fasteners, such as bone-pins, buttons of jet, stone, and bone, also jet and bone rings or loops, round or oval, to hold bands or belts together, besides the pins, brooches, and armlets of bronze in the barrows of later date.

Carefully prepared flint weapons and tools, and highly polished stone axes are well known to the mound-diggers. Indeed, our author states that "The barrows are found to contain examples of almost all the stone implements which occur elsewhere." On the contrary, bronze implements are represented by few forms (the plain axe, dagger, knife, drill, knife-dagger, and awl) in the barrows; the spear-heads, swords, flanged axes (paal-stabs), socketed celts, gouges, and chisels, turned up in hoards, not having been found with these burials. The plain axe of bronze, simply moulded after the form of the stone axe, seems to have been the earliest type, from which later modifications arose; and these mound-buried people were of too early a date to know any other.

Their personal ornaments were not very elaborate, nor were they made of gold, glass, ivory, or amber, so far as these researches show. They do not appear to have had any wealth, nor hides or grain to spare for exchange; and possibly they got their bronze and jet by plundering their neighbours. The "pottery of the barrows," carefully studied and richly illustrated, is regarded as having been prepared for the sepulchre alone;* the domestic vessels, well known on sites of habitations, being of a different manufacture, harder and more useful, and destitute of ornament. With all these matters are nearly concerned the social condition of the people (beyond the mere *hunting* state, and with gradations of society), their domesticated animals (few, and not clearly indicated: possibly ox, goat, sheep, horse, and pig), their progress in manufactures and art, and their belief in a future life; and these interesting points are lucidly handled in this Introduction. The entrenchments on the Wolds probably mark the living-places of this long-past

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* As these vessels were *spiritual*, and known to be practically useless, it is quite possible that the *flakes*, *potsherds*, and sometimes *pebbles*, so freely mixed with the earth of mounds, and thrown into graves of much later date (pages 11 and 12), may have been (certainly in earliest times) still more significant of the appliances of every-day life for the deceased. They would directly represent his weapons and tools, his strike-a-light and boiling-stones, and his means for dipping water and carrying hot embers. Poor indeed was the greatest of the heroes, on his dreary death-path, who had not "a sherd to take fire from the hearth, or to take water withal out of the pit." (*Isaiah* xxx. 14.)

people, some of whom were of the *long-head* (dolicho-cephalic) type, most of them, however, being *short-headed* (brachy-cephalic). The latter, who seem to have conquered the former, mixing to some extent with them, were closely related to the Danish stock. In turn they were overpowered by another (Anglian) long-headed race, in the 5th and 6th century after Christ, who brought in iron and silver, and whose descendants still constitute much of the population of the Wolds.

The long barrows belonged to the dolichocephalic oldest population; and the succeeding and dominating race buried their dead in the numerous *round* tumuli which form the chief subject-matter of this comprehensive, learned, and most interesting book. These later burial-mounds of the stronger *round-heads* were raised whilst bronze was still a scarce article, some of them perhaps about or soon after 1000 B.C.; and none of them can well be of later date than 500 B.C., as is well argued at page 131.

Professor Rolleston's description of the skulls, and general remarks on these pre-historic crania, is in itself a most valuable work to anthropologist, historian, and general reader. It comprises a practical treatise on craniography, a detailed account of the calvariæ submitted for his examination, an elaborate essay on pre-historic crania, and almost exhaustive treatises on the trees of pre-historic Britain, and the animals, such as the bee, fowl, deer, rabbit, dog, pig, sheep, ox, and others, associated, or supposed to have been associated, with pre-historic man. The amount of personal experience, of information communicated by friends, and of scholarly research into ancient facts and opinions, shown in these papers, is most striking, and will be fully appreciated by all readers, whether of general or scientific tastes. It not only proves, also, the great worth of the Linacre Professor of the Oxford University, his special industry and acumen, but supplies a noble supplement to Canon Greenwell's excellent "Record of British Barrows"—which is indeed an Essay towards the history of forgotten races, who have not only left their mark on English soil, but doubtless played their part in making up the composite character and constitution of Englishmen themselves.

THE ORIGIN OF THE WORLD.

WE know from the words of that illustrious philosopher, Mr. Ephraim Jenkinson, as recorded by the learned Dr. Primrose, that "The cosmogony, or creation of the world, has puzzled philosophers of all ages," and he adds, "Sanchoniathon, Manetho, Berosus, and Ocellus Lucanus have all attempted it in vain." In such distinguished company Principal Dawson need hardly be ashamed to take his place. At any rate the difficulties of the question are not removed by the publication of his book on the Origin of the World; and we fear that in what is really the main purpose of the book, namely, the reconciliation of the statements as to the creation of the world contained in the book of Genesis and the results of modern science, our author has not been much more successful than his predecessors. As by most, if not all, of the latter; the creative "days" of the Bible narrative are expanded by Principal Dawson into periods of unknown length, and the

table of creative periods given by him (p. 353) will perhaps show better than a long discussion what are the precise views he holds. It is as follows:—

PARALLELISM OF THE SCRIPTURAL COSMOGONY WITH THE ASTRONOMICAL AND GEOLOGICAL HISTORY OF THE EARTH.

Biblical Æons	Periods deduced from Scientific considerations
The Beginning.	Creation of Matter.
First Day.—Earth mantled by the vaporous deep — Production of light.	Condensation of Planetary bodies from a nebulous mass—Hypothesis of original incandescence.
Second Day.—Earth covered by the waters—Formation of the atmosphere.	Primitive universal ocean, and establishment of atmospheric equilibrium.
Third Day.—Emergence of dry land —Introduction of vegetation.	Elevation of the land which furnished the materials of the oldest rocks—Eozoic period of geology.
Fourth Day.—Completion of the arrangements of the solar system.	Metamorphism of Eozoic rocks and disturbances preceding the Cambrian epoch — Present arrangement of seasons—Dominion of "Existing Causes" begins.
Fifth Day.—Invertebrates and fishes, and afterwards great reptiles and birds created.	Palæozoic period—Reign of invertebrates and fishes.
Sixth Day.—Introduction of mammals—Creation of man and Edenic group of animals.	Mesozoic period—Reign of reptiles.
	Tertiary period—Reign of Mammals.
	Post-tertiary — Existing mammals and man.

The seventh and eighth days we may omit.

One has only to read over the simple narrative of the Biblical writer to see that a good deal of non-natural interpretation is necessary to arrive at this view of the meaning of the Genesiac cosmogony, even if we are prepared to accept without cavil the statements of the second column as giving absolutely the results of modern investigation. The Biblical writer says, "In the beginning God created the heavens and the earth," which is evidently a prefatory statement; and he then goes on to describe how the operation of Creation was performed, but he says nothing about the creation of matter, which, we may fairly presume, had he thought about it, would have puzzled him as much as it did Sanchoniathon, Berosus, and the rest of them, including Principal Dawson himself.

It is unnecessary to go further, as the table speaks for itself, and the reader will have little difficulty in recognizing the strained interpretation put upon the Scriptural record, in order to bring it into accordance with the assumed scientific results. It is clearly necessary to admit that some portions, at any rate, of the Bible are only the expression of human thoughts, and the most orthodox of us may safely regard this Genesiac account of the Creation as coming under such a category.

It need hardly be said that Principal Dawson does not accept the modern doctrines of evolution, but at the same time he admits that if we understand evolution as signifying merely the carrying out of the plans of the Creator

in the formation and perfecting of the Universe and its living inhabitants, there is nothing in such a notion that need "in itself be a bugbear on theological grounds." At the same time he considers that, before even the hypothesis of the gradual evolution of organic forms by descent with modification can be accepted, we require to possess a much larger array of facts; and the doctrine of evolution against which he specially protests "is the spontaneous evolution of nothing into atoms and force, and of these into all the wonderful and complicated plan of nature, without any guiding mind."

With regard to the origin and history of the human race, Dr. Dawson seems to have placed himself in a position of unnecessary difficulty by taking the date of the first appearance of man, the scriptural Adam, "not a myth or an ethnic name, but a veritable man," from such chronological data as can be derived from Scripture, and fixing it at from 4000 to 5000 years B.C. In discussing the human question, however, he admits the evidence proving the co-existence of man in Europe successively with the Mammoth and the Reindeer, and explains it after a fashion that will be hardly satisfactory to our readers. The Mammoth-men, according to him, are a portion of the pre-diluvian descendants of Adam, whilst the probably Eskimo-like Reindeer-men are post-diluvian!

While we find it impossible to agree with Principal Dawson either in the general tendency of his work or in many of its details, we must confess that it is a pleasant and readable book enough, and one that will doubtless be welcomed with delight by many who will look at it, rather from the theological than the scientific point of view. For ourselves, holding all spiritual religion to be a matter of faith and not of demonstration, and regarding the prevalent Bibliolatry of Protestant countries as a most mischievous element in modern Christianity, we cannot but regret that the author should have devoted so much of his time to the elaboration of the present work.

BIOLOGY.*

THIS is a volume of "The Library of Contemporaneous Science," which Messrs. Chapman & Hall are publishing, with a view to render good modern science more available to the educated classes. It appears that MM. Reinwald & Co. have made arrangements with certain foreign authors to do the original work, and that Messrs. Chapman & Hall have decided to present it in an "English dress," by means of some of the "best writers and recognised authorities here." It does not appear in the publishers' preface why English authors were not asked to do the original work, but possibly the affectation, as Herbert Spencer has it, which induces some men to depreciate the work of their own nationality, has not been without its influence.

Dr. Letourneau has produced a very good and readable book, far in advance of anything of the kind in this country, and his translator has performed by no means an easy task faithfully and very intelligently. It is a book which may be placed in the hand of an advanced student, of any member of the

* "Biology." By Dr. Charles Letourneau. Translated by William Maccall. 8vo. London. Chapman & Hall. 1878.

medical profession, and of most chemists; and if they will only condescend to study, the great mass of superficial readers will benefit by it. But it is not an easy book, for it deals with great problems; and as it is written conscientiously, it will rather astonish some people who follow blindly whatever the dominant school preaches. Letourneau is a philosophical evolutionist: he believes in spontaneous generation, and discredits all that one reads about germs. As a sensible man, he asserts the positivity of atoms and thus defines life: "Life is a twofold movement of simultaneous and continual composition and decomposition, in the midst of plasmatic substances, or of figurate anatomical elements, which, under the influence of this indwelling movement, perform their functions in conformity to their structure." If we did not know it before, this sentence would lead us to believe that life is sufficiently mysterious and incapable of formulation. The references to the positive part of Biology are good and up to the day; and the chapters which deal with function and reproduction and persistence are full of good original suggestions and careful quotations. Thus, in treating of the office of respiration, there is the following very suggestive sentence: "Behind every biological activity there is an oxydation of the anatomical elements; no organ escapes this law, and the nervous centres are as much in subjection to it as the other organic apparatus. Every thought, every volition, every sensation, corresponds to an oxydation of the living substance, as well as every secretion, every movement," &c. There is a singular blunder on page 269, in which a Malpighian body of the kidney does duty for one in the bladder. Further on, the Brownian movement is stated to be caused by phenomena of attraction at short distances and belongs to the domain of capillarity!—it has nothing to do, according to the author, with simple liquid currents. Due to the same cause that produces the motion of the vacuoles in the cavities of crystals, minute heat currents are certainly dynamical in this movement, which is so different from that of independent living things. Bathybius crops up, but its hypothetical nature seems hardly to have been understood; and an error of a distinguished British physicist is reproduced in the assertion that Dr. Mayer founded the "great doctrine of the unity of forces." Supposing that by this is meant the doctrine of the mechanical equivalent of heat and the theory of the conservation of energy, there is not the least justification for placing Mayer before Dr. Joule, of Manchester. Joule made the experiment, and proved by theory and practice what Mayer dreamed about and fancied, and never proved by experiment.

Everyone who has translated a French scientific work will sympathize with Mr. Maccall; and we do not wish in any way to detract from the credit due to him, when we suggest that before the book passes to a second edition some scientific man of standing should point out certain old-fashioned expressions, which would be all the better if Anglicized and modernized.

AMERICAN STATE PUBLICATIONS.

ONCE again we have to notice the wonderful series of scientific publications brought out under the auspices of the Government of the United States. And we may worthily begin with the records of the labours of the Geologi

al Survey of the Territories, conducted with so much spirit by Dr. F. V. Hayden, seeing that the grandest volume that we have to notice, just received, is issued by that department. This, which is the eleventh volume of the Report of the Geological Survey of the Territories,* contains a series of monographs of the families of North American Rodents by MM. Elliott Coues and J. A. Allen, the extreme value of whose work upon the Mammals of North America is so well known as to render any praise or criticism on our part quite superfluous. Our notice of this magnificent volume of more than 1,100 quarto pages must be limited to a general indication of its contents. The classification adopted by the authors divides the order Rodentia into the two well-known sub-orders, Simplicidentati, with two, and Duplicidentati, with four, incisor teeth in the upper jaw, the latter including the Leporidæ, or true Hares, and the Lagomyidæ, Pikas, or Calling Hares, both of which families are treated by Dr. Allen. Of the nine families into which the much larger group of the Simplicidentati is divided, the Muridæ, Zapodidæ, Saccomyidæ, Haplodontidæ, and Geomyidæ are described by Dr. Coues; and the Sciuridæ, Castoridæ, Hystricidæ, and Castoroididæ by Dr. Allen. Of these groups the Zapodidæ constitute a family established for the reception of a single species—the Long-legged Mouse or Jumping Mouse, originally described as a Jerboa, under the name of *Dipus hudsonius*, but which, according to Dr. Coues, exhibits characters distinguishing it quite as much from the true Dipodidæ as from the Muridæ. The family Castoroididæ is a new one, proposed for the reception of the great extinct Rodent, *Castoroides ohioensis*, the remains of which have been obtained from post-tertiary deposits in various parts of North America. This animal, which was about the size of an adult black bear, was long supposed to have been a gigantic beaver. Dr. Allen, however, places it in the Hystricine group. It is the largest known Rodent, except an extinct Capybara (*Hydrochærus*) described by Lund, from the Brazilian Bone Caves.

Each of the above families is treated monographically, its position in the system being discussed, its genera and species, and the habits of the latter, described, and its bibliography given. Under some of the families, the extinct North American species belonging to them are noticed, and in an appendix Dr. Allen gives a list of the known extinct Rodentia of North America, with short notices of those not referred to in the monographs. A second appendix contains a valuable bibliographical list of works relating to North American Mammals by Dr. T. Gill and Dr. Coues; and the whole concludes with a general alphabetical index to the volume. The illustrations consist chiefly of woodcut figures of the skulls of Muridæ, which are printed on five plates.

The ninth Annual Report of what we in England should regard as the more legitimate doings of the Survey, contains an account of the exploration of Colorado and adjacent territories, surveyed in the year 1875.† The actual

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* Report of the United States Geological Survey of the Territories. F. V. Hayden, U.S. Geologist-in-Charge. Vol. XI. Monographs of North American Rodentia, by Elliott Coues and Joel Asaph Allen. 4to. Washington. 1877.

† Ninth Annual Report of the United States Geological and Geographical Survey of the Territories, embracing Colorado and parts of adjacent Terri-

region examined comprised the southern and south-western portions of Colorado, with a belt, fifteen miles in width, of Northern New Mexico and Eastern Utah. The reports of the geological surveyors, MM. Peale, Endlich, and Holmes, which are illustrated with numerous maps and sections, give a most interesting account of the geology of that curious region, where the forms produced by peculiarities of rock-structure under the influence of denudation are amongst the most singular of geological phenomena. Mr. Endlich especially describes and figures some wonderful groups of earth-pillars, which occur in some localities in great numbers, and of a size compared with which those of Botzen are insignificant; 60–80 feet being the average height, whilst some examples rise to 400 feet. The rock of which these pillars are formed is a volcanic sand re-deposited by the action of water, and containing innumerable trachytic boulders of various sizes, which form the protective cappings of the pillars. Another extraordinary phenomenon is the formation of very regular arches of large size in narrow vertical walls of the same rock. Mr. Mudge's notes on the Tertiary and Cretaceous periods of Kansas are reprinted with additions at the close of the Geological Report on Colorado. Passing over the second part, which gives an account of the topographical labours of the Survey, the first article in the zoological section is a reprint, with additions, of a most valuable memoir by Dr. J. A. Allen, upon the history of the American Bison. Dr. Allen here furnishes us with an exhaustive treatise upon this interesting but ill-fated animal, whose disappearance from the face of the earth is certainly only a question of time. The story of its destruction, often from pure wantonness, at the hand of man, and its retirement as human inhabitants make their way into the wilderness, is a melancholy one, and is told in great detail by Dr. Allen, who foretells the speedy extermination of this great quadruped, and strongly urges that attempts should be made at its domestication, which does not appear to be a very difficult matter. Dr. A. S. Packard furnishes an excellent summary of the information acquired respecting the natural history of the Rocky Mountain Locust (*Caloptenus spretus*), the ravages of which in certain years are so serious. Dr. Packard believes that, by meteorological observations, the occurrence of "locust years" may be predicted, and preparations made by the farmers to receive their enemies. He also recommends the planting of forests along lines of railroad, and certain other precautions which would no doubt tend greatly to diminish the mischief done by this pest. Dr. Packard's report also refers to the Red-legged Locust (*Acrydium femur rubrum*), another destructive species in some districts, and to some others of more local occurrence; and he further reports on numerous injurious insects of various orders which inhabit the United States. This exceedingly interesting and valuable report is copiously illustrated with woodcuts and with nine plates of figures, and also with several maps, showing the range of some of the more destructive species. It is accompanied by a list of Coleoptera collected by Dr. Packard in California and Utah in 1875.

Another volume, which must take its place side by side with the grand

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tories; being a report of progress of the Exploration for the year 1875. By F. V. Hayden. 8vo. Washington. 1877.

volume on the Rodents of North America, is Dr. Elliott Coues' account of the Fur-bearing Animals of that continent*—a group of mammals whose history may perhaps be considered to appeal more strongly to our general interests than any others, except those directly serving as food for man. The Fur-bearing Animals are restricted in this volume to the family Mustelidæ, of which North America appears to possess nine—the Wolverine, Martens, Weasels, Skunk, Badger, Otter, and Sea Otter. These animals are all described in scientific form, and the descriptions are accompanied by a complete *résumé* of all the particulars relating to the natural history of the animals, which have been accumulated by a long series of observations on the part of the zoologists of the United States upon the species living within their range, and by the, perhaps, somewhat interested remarks of the hunters and trappers, who are, to a considerable extent, dependent on their knowledge of the habits of the animals for the successful prosecution of their trade. In fact, the volume furnishes an admirable monograph of the North American species of the carnivorous family of which it treats. The osteological characters, and especially the cranial peculiarities, which appear to be of special importance, are fully described, and the latter are illustrated by good figures, occupying about 20 plates.

The Ethnography and Philology of the Hidatsa Indians, better known, perhaps, as the Grosventres, constitute the subject of another volume of the miscellaneous publications of Dr. Hayden's Survey.† Mr. Washington Matthews, the author, gives an elaborate account of this tribe of Indians—the remnants of which at present live in the village at Fort Berthold, in Dakota,—which he follows up with a grammar and a dictionary of the principal words of their language. The Ethnographical section commences with an interesting account of the village at Fort Berthold, which is inhabited by members of three distinct tribes of Indians—the Hidatsa, the Mandans, and the Arickarees,—and it is a remarkable fact that, according to Mr. Matthews, these Indians, although living in close juxtaposition, and often intermarrying, still retain their respective languages quite uncorrupted, although they generally possess a knowledge of those of the other tribes; and, in fact, it is not uncommon among them to find persons who can speak four or five languages fluently. The Hidatsa, or Minnetarees, with whom the Crows appear to have been united, were, even in former days, a comparatively cultivated tribe, practising agriculture to a sufficient extent to enable them to dispose of corn to their neighbours; and the general testimony of travellers, which is fully endorsed by our author, is highly in their favour. Mr. Matthews gives an account of their habits, customs, and superstitions, which may interest the general reader as much as the philological treatise will gratify the student of the American Indian languages.

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* "Fur-bearing Animals: A Monograph of North American Mustelidæ," &c. By Elliott Coues, U.S. Geological and Geographical Survey of the Territories, Miscellaneous Publications, No. 8. 8vo. Washington: Government Printing Office. 1877.

† "Ethnography and Philology of the Hidatsa Indians." By Washington Matthews, U.S. Geological and Geographical Survey, Miscel. Publ., No. 7. 8vo. Washington. 1877.

The Descriptive Catalogue of Photographs of North American Indians,* by Mr. W. H. Jackson, contains a good deal of information about the Indian tribes, which will be found interesting, even without the admirable series of photographs to which it is intended as a guide. The last publication of the Survey of the Territories that we have received is a fourth edition of the Lists of Elevations† in the country surveyed by Dr. Hayden and his staff. These lists were first published in 1872, when they formed a 12mo pamphlet of 31 pages; the additional observations since made have brought the work up to 160 closely-printed 8vo pages of tables of elevations, illustrated with a large contour map.

A most valuable volume is the Report of the Commissioner of Fisheries ‡ for the years 1873–5, which contains not only the Commissioner's formal statement of the results of operations carried on under the auspices of the Commission during those years, but also a series of appendices giving the most varied information from all sources upon subjects connected with Fish and Fisheries. From these documents we learn that the system of artificial propagation is being adopted with great energy by the Americans, especially in the case of the Atlantic salmon, the Californian salmon, and the shad; and that the eggs and young fry of these fishes have been transported into new waters with a considerable amount of success. With regard to the shad, the Commission even attempted to send a supply of the newly-hatched fry from America to Germany, with a view to the introduction of the American species into European rivers, in return for a large consignment of young Rhine salmon sent by the German Government to America. The experiment was unsuccessful, but the gentlemen sent in charge of the fish think that it would not be difficult to transport the shad to Europe by placing the eggs in an ingenious hatching apparatus which they have invented, and which is described and figured in the present volume. In the appendices, besides elaborate reports upon the steps taken by the agents of the Commission for carrying out its objects in various parts of the United States, we find translations of important memoirs on food fishes and their propagation, and on fisheries, which have been published during the last few years in different European countries; the most important being those from Danish, Swedish, and Norwegian sources, which may be regarded as peculiarly inaccessible to most English readers. There is also a translation (from the French) of a valuable Russian report on Fisheries and Seal-Hunting in the White Sea, the Arctic Ocean, and the Caspian. The book, in fact, contains an immense mass of information of the highest value to the ichthyologist. There is also a brief report upon the results of dredgings made in 1873 in the Gulf of Maine, and a list of the Marine Algæ of the United States, both arising out of the investigations of the marine

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* "Descriptive Catalogue of Photographs of North American Indians." By W. H. Jackson, Photographer to the Survey. Miscel. Publ., No. 9. 8vo. Washington. 1877.

† "Lists of Elevations, principally in that portion of the United States West of the Mississippi River." By Henry Gannett. Fourth edition. Miscel. Publ., No. 1. 8vo. Washington. 1877.

‡ "United States Commission of Fish and Fisheries. Part III. Report of the Commission for 1873-4 and 1874-5." 8vo. Washington. 1876.

natural history of parts of the coast of the United States, which are undertaken every summer by the officials of the Commission.

In the Report of the Commissioner of Agriculture for 1875* we have a volume which, although not so interesting throughout to the scientific naturalist as that of the Fisheries' Commission, nevertheless contains several important contributions in addition to those of a more purely industrial bearing. The entomologist, Dr. Townend Glover, furnishes an account of the habits of those species of the Heteropterous Rhynchota, or Bugs, which are either injurious or beneficial to man; Mr. George Vasey, the botanist, gives a list of the Forest Trees of the United States, a subject which is further illustrated by a long and elaborate report, with maps, on the statistics of forestry; the microscopist, Mr. T. Taylor, notices the microscopic appearances of cellulose and starch, and contributes a paper on the diseases of fungal origin known as "Cranberry rot and scald"; and Mr. J. R. Dodge has a long paper on the Sheep and Wool of the World.

Of the Smithsonian Report for 1876† we need say little more than that, besides the formal reports of the progress of the Institution, it contains the usual selection of memoirs upon various scientific subjects. Among these, translations of Arago's Eulogy on Gay Lussac, and of a biography of the present Emperor of Brazil, will be read with interest; as also a memoir on "Kinetic Theories of Gravitation," by Mr. W. D. Taylor, in which the author discusses the various speculations that have been put forward on this subject. Several original papers on American Ethnology, illustrated with figures of pottery, articles of stone and wood, and curious earthworks, are also of much interest.

HUXLEY'S INVERTEBRATA.‡

SOME twenty years ago, not long after he succeeded the late Professor Edward Forbes at the School of Mines, Professor Huxley commenced the publication, in the "Medical Times and Gazette," of a series of lectures on Comparative Anatomy, which, to the regret of many students of Zoology, came to an untimely end. Subsequently, in 1871, he brought out his well-known "Manual of the Comparative Anatomy of Vertebrated Animals," which is now succeeded by a corresponding volume on the Invertebrata.

It is hardly necessary to say that this book, which forms a stout little volume of some 700 pages, is a most welcome addition to our stock of Zoological literature. The author's eminence as an original investigator (first established by most valuable researches upon several types of invertebrate animals), his intimate acquaintance with all the modern literature of the subject, his experience as a teacher, and his wonderful power of lucid exposition,—all combine to assure us *à priori* that in his present work we shall have, what

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* "Report of the Commission of Agriculture for the year 1875." 8vo. Washington. Government Printing Office. 1876.

† "Annual Report of the Board of Regents of the Smithsonian Institution, showing the Operations, Expenditures, and Condition of the Institution for the year 1876." 8vo. Washington. 1877.

‡ "A Manual of the Anatomy of Invertebrated Animals." By Thomas H. Huxley, LL.D., F.R.S. *Sm. 8vo. London*: Churchill. 1877.

has long been much wanted,—a thoroughly good and trustworthy English treatise on the morphology of the Invertebrates. And a pretty close inspection of it, whilst revealing one or two points to which we might, perhaps with some ground, demur, shows, nevertheless, that, so far as can be expected from a manual dealing with so vast a field, these anticipations are fulfilled. Throughout the book the structure and development of the animals forming the great natural groups of Invertebrata are admirably described, and many particulars as to their relations to the world outside of them are given.

In carrying out this plan the author has not attempted to give any prominence to the question of classification, his object being, as he says in his preface, to give clear ideas of the morphology of the great natural "orders" (classes of most zoologists), leaving the question of larger natural divisions to some extent on one side; and in this way, while the different well-known groups are brought together under definite sections, certain others, of doubtful affinities, are treated of in a final chapter, together with one or two which have been established since the earlier portion of the work was printed. But this apparent disregard of classification is due to no depreciation of its importance, but rather to Professor Huxley's feeling, that at the present moment the science of zoology is still in a somewhat uncertain state, the old hard and fast lines of system having been considerably broken in upon, whilst no new views have been put forward with sufficient force to take their place. According to the author (and we think this expression of opinion may perhaps have a beneficial influence on the minds of some of our younger zoologists), classification is the "superstructure and outcome" of morphology; or, in other words, the best classification is, as it was always considered by the older zoologists, the best exposition of the sum of our knowledge of the organisms under consideration.

One is the better pleased to find a naturalist like Professor Huxley taking this view of the present state of Zoology, because he is, as his new work sufficiently shows, deeply imbued with the views of development maintained by Häckel; and both that distinguished professor and many of his followers adopt a rather strongly dogmatic tone in expressing their opinions on systematic points. We are all familiar with the beautiful genealogical trees which have lately been so often put forward. Professor Huxley treats us to nothing of the kind; but he speaks of phylogeny as "a special branch of biological investigation;" and adds: "In practice, the reconstruction of the pedigree of a group from the developmental history of its existing members is fraught with difficulties. It is highly probable that the series of developmental stages of the individual organism never presents more than an abbreviated and condensed summary of ancestral conditions, while this summary is often strangely modified by variation and adaptation to conditions; and it must be confessed that, in most cases, we can do little better than guess what is the genuine recapitulation of ancestral forms, and what is the effect of comparatively late adaptation." He hopes that by phylogenetic investigations, founded on the study of ontogenetic development and of fossil organisms combined, "a perfectly safe foundation for the doctrine of Evolution" may be arrived at.

With regard to the fundamentals of the doctrine of Evolution, Professor Huxley is equally candid. He says: "Three views may be taken of the [illegible] variation:

"*a*. In virtue of its molecular structure, the organism may tend to vary. This variability may either be indefinite, or may be limited to certain directions by intrinsic conditions. In the former case, the result of the struggle for existence would be the survival of the fittest among an indefinite number of varieties; in the latter case it would be the survival of the fittest among a certain set of varieties, the nature and number of which would be predetermined by the molecular structure of the organism.

"*b*. The organism may have no intrinsic tendency to vary, but variation may be brought about by the influence of conditions external to it; and, in this case also, the variability induced may be either indefinite or defined by intrinsic limitation.

"*c*. The two former cases may be combined, and variation may to some extent depend upon intrinsic, and to some extent upon extrinsic, conditions.

"At present it can hardly be said that such evidence as would justify the positive adoption of any one of these views exists."

With this quotation we may take leave of Professor Huxley's book, recommending it to our readers as the most moderate and philosophical exposition of the views of the advanced school of Zoologists that they are likely to meet with for some time. The little volume is very freely illustrated with woodcuts, which, if not first-rate as works of art, generally represent well enough the objects they are intended to show.

ELEMENTS OF CHEMISTRY.*

WHEN the first edition of the Chemical Physics appeared twenty-three years ago, it was pointed out by the late Professor Miller that it was devoted to a subject upon which no elementary work had then appeared in this country since the publication of the excellent treatise of the late Professor Daniell. The interval has seen the production in an English garb, of some translations of text-books in which Physics has been treated from a chemical point of view, but the usefulness of the "Chemical Physics" has not waned. In the fifth edition, issued in 1872, so much additional matter was incorporated that the book was half as large again as the first edition; the present is nearly double its size. The main branches of the subject are, with a few slight modifications, treated in the same order as heretofore. In the chapter on the air-pump a description and woodcut are provided of the Sprengel pump, the complex form of which will startle a beginner; reference is made in this place to the simplest form of the instrument to be found in later pages; it may, however, be missed, as the number attached to the figure is misprinted. It is interesting, in passing, to observe that the best exhaustion obtained by the Sprengel pump was in one instance $\frac{1}{93702000}$ of the atmosphere. Allusion is made to the water barometer placed by Daniell "in the hall of the Royal Society:" we believe that an instrument of this kind, set up

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*"Elements of Chemistry: Theoretical and Practical." By William Allen Miller. Part I. Chemical Physics. Sixth Edition. Revised by Herbert M'Leod. 8vo. London: Longmans. 1877.

a few years since, still forms a feature of the Technological Museum in the Crystal Palace.

In the chapters treating of solution of substances we find for the first time that Mr. M'Leod still retains a form of nomenclature attempted to be introduced some years since, but which never obtained general acceptance; we refer to such expressions as "magnesic and zincic sulphate." "Magnesic" is not nice, but "zincic" is "most intolerable and not to be endured." Further on, when dealing with the separation of bodies by cold, we find references to the observations of Rae, and the recent experiments of Buchanan and Guthrie. It is interesting to trace, under Light, the subject of prismatic analysis, of which so little was said in the first edition, extended to a report, rich in recent results, in the present edition; it is brought down to date by reference to the lines of the new metal gallium. The woodcuts taken from photographic spectra of the elements on pp. 277-8 are sadly blurred in the printing. As the production of cold by vaporization has attracted considerable attention of late, we were led to expect, what we do not find, a description of Carré's newer and very elegant apparatus for the freezing of water, based on Leslie's method, which is however mentioned, and which it so beautifully illustrates. The rapidity with which a pint of water can be frozen by its means renders it a most valuable aid in a chemical or physical laboratory, as well as a means of producing a very striking lecture experiment. Again, we cannot help feeling that the reader will experience some difficulty in grasping the principle of Holtz's electrical machine for want of an illustration. The machine is of increasing practical importance from the fact that it will remain charged for many hours. We regard these as shortcomings, as we have noticed in another part of the work more than one illustration of the same apparatus. Many examples could be quoted in testimony of the aim having been in all the chapters to incorporate all recent scientific results of established importance, and we may content ourselves by alluding, in support of this, to the fact that the declination and inclination of the magnetic needle for the present year (1877), as registered at Kew Observatory, are given, and to a note on the remarkable experiments of De La Rue and Müller with their new form of battery. The meanimg of an expression used in this note, "a condenser of 44.8 microfarad capacity," will puzzle the general reader, while reference to the index will throw little light on the problem.

THE ART OF ELECTRO-METALLURGY.*

THE present volume is, we believe, the most recently published of the valuable series of text-books of science which are being issued by Messrs. Longmans "for the use of artisans and of students in public and science schools." The author has provided a vast amount of information on the subject, and has increased the usefulness of his text-book, so far as some of his readers are concerned, by supplying, page by page, abundant references to original memoirs, thus placing those who consult his book in a position to

* "The Art of Electro-Metallurgy, including all known Processes of Electro-Deposition." By G. Gore. Sm. 8vo. London: Longmans. 1877.

gather any additional detailed information respecting the various processes to which they may have occasion to refer.

We cannot turn over the pages of the historical sketch which forms the opening chapter of the book, without experiencing a feeling of satisfaction at the manifestly large share taken by our countrymen in the development of this branch of industrial science. Next we have an exposition of the principles and laws of "Electro-Metallurgy" which is for the most part all that could be desired. The atomic weights of elementary substances, as given in this chapter, vary considerably in some cases from those at present accepted. When speaking of the means of measuring a galvanic current, the author states that "the instruments usually employed for that purpose are either a galvanometer or a voltameter," and further, that "what is termed 'a tangent' one may be conveniently employed." The reader will hardly gather from this that the two forms of galvanometer differ very materially as regards their use as *measurers* of currents. What is generally known, is that in the instrument usually termed the galvanometer (or multiplier), the deflections of the needle, while increasing with the intensity of the current, bear no simple relation to it, and the relation has to be determined experimentally for each apparatus; in the case of the tangent compass, however, the tangents of the angles to which the needle is deflected by the currents are proportional to the currents causing the deflections. From the theoretical we pass to the practical division of the book, which occupies about one half of the volume, and is devoted to the processes employed for the electro-deposition of metals and metalloids. Class I. is intituled "Gaseous Metals," and *they* are hydrogen. Although hydrogenium is referred to, and Böttger's modification of an earlier experiment is described, the name of Graham is conspicuous by its absence; the author directs attention to his own researches on the electrolysis of hydrofluoric acid and hydrochloric acid. He speaks in this chapter of water as a "salt" of hydrogen (p. 94); then we find "arsenic acid" is a "salt" (p. 97), black oxide of manganese is a "salt" (p. 250), and caustic lime is a "salt" (p. 292). What, we ask in despair, is *not* a "salt"? Mr. Gore appears to have lost sight of the chief aim of the series of text-books of which his forms one; they are intended to serve for the use of practical men, and as regards style and subject-matter to be within the comprehension of working men, and suited to their wants. Our chemical nomenclature is unhappily difficult and bewildering enough as it is, and every effort should be made to simplify it and render it comprehensible to every reader. Will those who use his book know that by "chloride of ammonia," "chloride of ammonium" and "sal ammoniac" three names used within a few pages of each other, it is intended to indicate the same substance? Again, on one page we are told that "(iron) protosulphate" is also called "green vitriol"; in the next paragraph we read of "ferrous sulphate"; in the next of "protosulphate (green copperas)"; in the next but one of "ferrous sulphate (green vitriol)"; and again, in the same paragraph, of "sulphate of iron." In ringing the changes which are possible with the names of this substance the author has in this short space hardly omitted one. The article on the electro-deposition of silver is very full and very useful. The quantity of silver used in plating wares which are sent in such large quantities to the colonies is stated to be about one ounce to the square mile! In Birmingham iron snuffers are sometimes "silvered" wholesale at

as low a price as fourpence per pair, and hooks and eyes at one penny per pound. They manage these things better in France, where electro-plating is regulated by law, the manufacturer being required to weigh each article when ready for plating, in the presence of a comptroller appointed by the Government, and to report the same article for weighing again when the plating has been done. Electro-gilding does not appear to be a costly process; a silver thimble may be handsomely coated, so as to have the appearance of being all gold, for threepence. Among the recipes for cleaning silver we find no mention of an excellent method in use for freshening the surface of filigree work. A plan which is recommended here is somewhat curiously worded: "Silver may be cleaned in water in which potatoes have been boiled, and a superior polish is thus imparted to them." Under copper we find some interesting particulars regarding the copying of wood engravings in that metal. Successful deposits of large wood blocks of the *Illustrated London News* have been formed and taken off in eight hours; and electrotype blocks used in printing *The Times* are stated to have furnished twenty million impressions before the surface was unfit for further use. As regards the deposition of nickel, to which attention has recently been drawn, we learn that although the metal is much less expensive than silver, the cost of nickel-plating is not proportionately less. In the Special Technical Section of the art of electro-metallurgy, the author describes the various forms of batteries in use; figures of the forms devised by Wollaston, Smee, and Daniell are provided, the batteries of Bunsen and Grove, however, are only illustrated by the coke bar used in the one, and the porous cell employed in the other. The use of batteries has in some cases been superseded by the introduction of magneto-electric machines and thermo-electric piles. A gramme machine, such as is employed by the firm of Christophle of Paris, when worked with one horse power at a speed of 300 revolutions per minute, will deposit 600 grammes of silver per hour. Clamond's pile, of the kind used in Birmingham, London, Sheffield, and other places, when burning 150 litres of gas per hour, will deposit one kilogramme of copper.

FERNS.*

THE study and cultivation of those interesting and often exquisitely beautiful plants, the Ferns, are now so very general that it need be no matter of surprise to find that the literature relating to them is constantly on the increase. We have now before us two excellent works on ferns. One of them is a new edition of Mr. John Smith's handbook of ferns, in which that gentleman, whose experience in this department of botany, and especially in the cultivation of the plants during his long service as Assistant Curator of the Botanic Gardens, at Kew, rendered him one of the first

* "Ferns: British and Foreign. The History, Organography, Classification, and Enumeration of the Species of Garden Ferns. With a Treatise on their Cultivation, &c., &c." By John Smith, A.L.S. New and Enlarged Edition. 8vo. London: Hardwicke & Bogue. 1877.

"The Fern World." By Francis George Heath. 8vo. London: Sampson Low & Co. 1877.

authorities on the subject, gave a regular systematic account of all the cultivated British and foreign species of these plants. Mr. Smith, having the interests of the fern-grower especially before him, commences his work with a history of the introduction into this country of those exotic species which are or have been cultivated in our ferneries. His next section contains a brief but excellent organography of ferns, giving a description of the characteristic parts of the plants, to serve as an introduction to the systematic section of his work. In his classification he follows the "Species Filicum" of the late Sir William Hooker, and characterizes all the genera of ferns and fern-allies which possess species either native to this country or which have been cultivated here, the species, with their synonyms, being enumerated under each genus. In this new issue of his work Mr. Smith has added an appendix, in which the species introduced since 1866, the date of publication of his work, are treated in a similar fashion, the new information being brought into relationship with the old by means of the numbers of the genera. In the preparation of this appendix, which renders the work complete to the present date, the author has had the valuable aid of Mr. J. G. Baker and Mr. William Gower, of Kew. The work concludes with a long and elaborate chapter on the cultivation of ferns. Its descriptive section is illustrated with a great number of exceedingly good outline woodcuts, in which the characteristic parts of each genus are well shown, whilst a frontispiece furnishes similar illustrations to the general organography. To the student of ferns Mr. Smith's work, with its careful descriptions, good figures, and copious synonymy, will prove a most valuable acquisition.

The second work to which we have to call attention, although it also deals to a considerable extent with fern-cultivation, is of a very different character. The author, Mr. F. G. Heath, some time ago published a very nice little book under the title of the "Fern Paradise," which was really, as he called it, "a plea for the cultivation of ferns," and the success which this deservedly met with has induced him to try his luck with a larger venture on the same track. Mr. Heath's "Fern World" will be a very acceptable drawing-room book, but at the same time it possesses certain qualities which ought to earn for it a better position. The author writes with great enthusiasm of the plants of the culture of which he has in a manner constituted himself an apostle—he carries his reader with him in search of them to the beautiful combes of Devonshire, and discourses with much pleasant unction on the joys of fern-hunting among scenes to which his favourite plants lend so much of their charm. But before indulging us with these glimpses of "Fernland" he lays before us a store of solid food in the shape of a brief but good sketch of the general structure, character, and mode of growth of ferns, with notes on their classification, distribution, uses, and folk-lore, followed by several chapters on the culture of the plants. The illustrations of this portion of the book consist of a few woodcut figures in the text. The section on ferny scenery is illustrated with four beautiful views of localities in Devonshire.

The last part of Mr. Heath's work, occupying rather more than half his volume, is devoted to a description of the British species of ferns. His descriptions are not formal, but sufficiently precise to enable the species to

be easily determined, and the author has avoided giving a detailed account of the numerous minute variations to which some of his favourites are subject, and has done wisely, as we think; but we cannot approve of his remarks on this subject, which would seem to convey to his readers that these minute distinctions are absolutely needless, whereas to a great extent they are only needless for his purpose. In other respects Mr. Heath's book is so good that we are sorry to see him making statements *ad captandum vulgus*. We would also suggest as an improvement to this section of the book the addition of a synopsis of the genera; at present the generic and specific characters are combined in the descriptions, and perhaps this arrangement may be retained with advantage; but such a statement of the characters of the genera as would enable the reader to understand what is meant by a genus, and what is the significance of the scientific names employed, would certainly place the work on a much higher footing. The descriptions are well illustrated by coloured figures of each species (generally reduced in size), produced by a photo-lithographic process from the objects themselves; they are generally well executed and very characteristic.

PHYSIOGRAPHY.*

IT needed very little of the prophetic spirit to foresee that the introduction of physiography into the syllabus of the Science and Art Department would be speedily followed by the publication of text-books of physiography. Dr. Mackay is first in the field, and as an experienced hand at geographical compilation, he has succeeded in producing a neat little work, which may be found useful to students who think of facing the May examinations at South Kensington. Whether any good will result from the substitution of physiography for physical geography, is quite another matter, with which Dr. Mackay has of course nothing whatever to do. It is believed by very high authorities that physiography, or the science of nature in general, offers the best means of introducing young people to a little knowledge of geology, biology, physics, chemistry, astronomy, and what not. But it must also be acknowledged that so comprehensive a subject can be mastered only by one who commands a good deal of scientific knowledge. Physiography is indeed, in one sense, the sum and substance of all natural science, though in another sense it may be regarded as the starting point of the scientific circle. With so much matter to compress into so little space, we are surprised to find that Dr. Mackay has a good deal to say about the Great Pyramids, and that he should think it worth while to advocate the use of the ancient sacred cubit against what he calls "the much vaunted French mètre." But our surprise culminates when we find him going out of his way to explain how a change in the inclination of the earth's axis might have brought about the Noachian deluge, and have indirectly affected the longevity of man!

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* "Physiography and Physical Geography." By the Rev. Alex. Mackay, LL.D., F.R.G.S. Small 8vo. Edinburgh and London: Blackwood & Sons. 1877.

"Physiography: an Introduction to the Study of Nature." By T. H. Huxley, F.R.S. Small 8vo. London: Macmillan. 1877.

The preceding notice was intended for insertion in our last number, but had to be omitted for want of space. We regret this the less as it enables us to notice at the same time the recently published handbook of the inventor of Physiography, Professor Huxley, which enables us to see more clearly what is his idea of the best mode of teaching the new science. It appears to us, after a careful perusal of his book, that the difference between Physiography and Physical Geography consists almost entirely in the form in which the facts and inferences are presented to the learner. There is literally nothing in the volume that might not, or indeed ought not, to be taught in any treatise on Physical Geography, although perhaps a greater development is given to the explanations of certain collateral matters, such as solar physics and the chemistry of the atmosphere and of water, than is absolutely necessary for geographical purposes; but instead of arranging his subjects in the dry systematic form usually adopted, commencing with an account of the cosmical relations of the earth and gradually descending to details, he starts from the concrete example of the Thames and its valley, and works out from this comparatively narrow limit to the general phenomena of the earth and the universe. In fact the Thames being his text he preaches a sermon on the natural phenomena presented by the world of which it forms a part. It is easy to follow the sequence of thought involved in this operation. Thus, the geography of the Thames and its basin being described, the source of its waters naturally comes next into consideration, and in connection with this the phenomena of the great circulation of water on the surface of the earth are treated of; the atmosphere as one link in the chain is then described, and the consideration of the composition of pure and natural waters leads directly to the explanation of the action of moving water, whether liquid or frozen, in disintegrating and degrading the land-surfaces over which it passes. The sea also is noticed as having its work to do in the same direction. On the other hand there are compensating agencies at work in the action of earthquakes and volcanoes, in the slow secular upheavals of the land, and in the action of living creatures, tending more or less directly to restore the equilibrium of land and water, and these having been discussed, the geological facts revealed by the study of the basin of the Thames can be profitably considered. Then, by a not unnatural transition from the Thames valley to what lies outside it, the author passes to a general consideration of the distribution of land and water on the surface of the globe, to an account of the figure and movements of the earth, and finally to a description of the phenomena presented by the sun, with especial reference to its influence, and that of the moon, upon the surface of our earth. As he says, "the sun is revealed as the grand prime mover in all that circulation of matter which goes on, and has gone on for untold ages, within the basin of the Thames; and the spectacle of the ebb and flow of the tide under London Bridge, from which we started, proves to be a symbol of the working of forces which extend from planet to planet, and from star to star, throughout the universe."

It is, in fact, this idea of starting from the familiar, and working outward to the larger conceptions, that is the ruling idea of Professor Huxley's plan in this little work. Of course, it is impossible to tell how much of the credit of producing it is due to Professor Huxley, and how much to Mr.

Rudler, who, as we are told, prepared the substance of the lectures on which the work is founded for the press, but certainly, between them they have produced a most charming little book, and one which, as a means of self-instruction for the young, we cannot but regard as the best guide extant to a general elementary knowledge of the phenomena of the world we live in. We should, however, doubt its fitness for use as a school book, although it may probably serve, as Professor Huxley seems to hope, as a guide to teachers in giving a course of instruction to their classes. We may add that the little volume is illustrated with a good many wood engravings, and with several useful maps printed in colours.

THE FLORA AROUND LONDON.*

FORTY YEARS have elapsed since the publication of the "Flora Metropolitana," during which period the nature of the vegetation of the London district has to a certain extent been altered, and in some places even destroyed, owing to the clearing, enclosing, and building which has been constantly going on there, so that the character of many of the localities mentioned by Mr. Cooper in the work above mentioned have changed, and the plants which formerly grew there have disappeared. Dr. de Crespigny has therefore conferred a benefit on the botanical student and collector of plants by the compilation of a new London flora.

Availing himself of the descriptive works on the subject, and supplementing the information derived from them by extensive personal investigations, the author has recorded more than 1,200 species of plants which have been observed within a radius of thirty miles around London. These are arranged in alphabetical order under flowering plants and cryptogams; their chief localities are given. A series of seventy-five localities is appended, with lists of the plants to be found in each of them, preceded by short descriptions of the physical features and other characters. The object of the author is to show the actual occurrence of plants at the present time, rather than their local history in the past, and thus to render his work a handy guide to the botany of the metropolitan districts. This unambitious purpose its arrangement particularly adapts it to fulfil: the general list will tell the student where he may expect to find any particular plant of which he is in want, and the list of localities will inform him what he ought especially to look for in visiting them; and as the book is so small that it may be easily carried in the pocket, it can hardly fail to prove exceedingly useful to the practical botanist.

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* "A New London Flora, or Handbook to the Botanical Localities of the Metropolitan Districts." By E. Ch. de Crespigny, M.D., M.R.C.S. 8vo. London: Hardwicke & Bogue. 1877.

SCIENTIFIC SUMMARY.

ANTHROPOLOGY.

MORPHOLOGY of the Human Teeth.—Dr. E. Lambert, of Brussels, after a careful study of the characters of the teeth in the different races of man, has formulated the important conclusions at which he arrives as follows:—

In the *white* race the triturating surface of the canines does not project beyond that of the other teeth; the two premolars are of equal volume; the first true molar is the largest; and the last, or "wisdom-tooth," the smallest.

In the *black* race all these peculiarities are reversed; the canines project beyond the adjoining teeth, the posterior premolar is larger than its fellow, and the true molars increase in size backwards.

In the *white* race the molars usually have only *four* cusps; in the black, *five*. If in the white race there are five, it is the first molar that has them; in the black race it is the last.

In the *yellow* race there is usually, as in the black, a slight increase in the size of the true molars from front to back, and there is a fifth cusp on the hindmost molar.

In the black race the incisors are larger in diameter than in the white, and the triturating surface of the canines is larger than in the adjoining teeth.

In the black race there is a slight diastema, which does not exist in the white, and the inner tubercle of the premolar is less developed than the outer, as in the Anthropoid apes. The first lower premolar, also, has often a feebly developed inner tubercle, which is another slight manifestation of resemblance to the apes.

In the black race the upper molars have the antero-posterior diameter equal to the bilateral; in the white it is always smaller, whilst the yellow race show an intermediate form.

There is more difference in the teeth between the black and yellow races than between the yellow and white; but the Malay branch, the type of the brown race of D'Omalius, seems to be transitional between the black and yellow with respect to the general volume of the teeth, the number of cusps of the large lower molars, and the tendency to increase of size in the molars posteriorly.

The American race, the red race of D'Omalius, which is usually united with the yellow, presents so nearly the same dentary characters as the bla

race that Dr. Lambert unites the two. The Australians, Tasmanians, and New Caledonians in some respects present an exaggeration of the dentary characters of the African negro, and they are also more strongly prognathous.

The crania from the caves of Furfooz (Belgium) have the lower molars decreasing in size backward, as in the white race; and this is also the case with seventy neolithic crania exhumed at Hastières. But the palæolithic lower jaw from La Naulette (Belgium) approximates most to that of the Australian and New Caledonian races, thus showing a resemblance in the age of the mammoth between man in Belgium and the existing races of the antipodes.—(*Bull. Acad. Roy. Sci. Belg.* 1877, No. 5; and *Amer. Journ. Sci.* October 1877, p. 322.

ASTRONOMY.

Sun's Distance deducible from the British Transit Observations, December 9, 1874.—Those observations by the British observing parties, which of themselves suffice to give a determination of the sun's distance, have been skilfully dealt with by Captain Tupman, and the result may be regarded as at least affording a means of estimating the value of the method employed. The Astronomer Royal, indeed, believes (naturally enough, perhaps) that the result will be accepted as more trustworthy than any before obtained, or than the mean of the results obtained by all the best preceding observations. Time will show, we believe, as it did in the case of his Harton Colliery experiment for determining the earth's mean density, that astronomers will not accept a result whose wide discordance from former measures (closely accordant *inter se*) indicates that the method employed is defective. Full credit will be given to the Astronomer Royal for his success in demonstrating the untrustworthy nature of Delisle's method of observing transits for determining the sun's distance. Sir G. Airy's opponents, in the controversy of 1872–4, only rendered the defectiveness of Delisle's method probable by reasoning more or less depending upon theoretical considerations. He has succeeded in demonstrating the point practically—at some considerable cost to the nation, but that is merely a detail. Whether this view of the *gist* of his results is correct, or that which he himself adopts, can be inferred, we believe, from the following facts:—In 1854 Hausen deduced for the solar parallax 8″.916 (we refrain here and throughout our remarks from giving decimal figures beyond the third, as no reliance whatever can be placed upon them). Other results at that time ranged between the values 8″.80 and 8″.96. Amongst such results should specially be noted one which all Greenwich united to honour, Mr. Stone's deduction of 8″.92 as the most probable result of the transit of Venus observations in 1769. Latterly Professor Newcomb, of America, has carefully gone over the whole subject, selecting with special skill the methods on which most reliance can be placed,

and the best sets of observations. He has thus obtained the following six results from the six best methods:—

Lunar equation of the earth	8″.809
Lunar parallactic inequality	8″.838
Micrometric observations of Mars (1862) . .	8″.842
Meridian observations of Mars (1862) . . .	8″.855
Transit of Venus 1769 (Powalky's reduction) .	8″.860
Foucault's experiment on light	8″.860

Giving to these results their proper weights, Newcomb obtains as the most probable mean 8″.848, corresponding to 92,393,000 miles as the sun's mean distance. Leverrier, again, from the method which he considered would in the long run supplant all others, deduced the parallax 8″.86.

Sir G. Airy announces as the result of the British expeditions, so far as the Delislean method is concerned (for fortunately many British Halleyan observations in the south were made which will be of service when combined with similar observations in the north by other nations), a solar parallax of 8″.760, corresponding to a distance of 93,321,000 miles, or nearly a million miles more than the value regarded by American, Continental, and a large number of British astronomers as most probable, and three-quarters of a million miles outside the range of probable error in the former evaluation.

This of itself would show that the Delislean method is as untrustworthy as was asserted before the transit. But besides this evidence from the comparison of the new result with those before obtained, the results themselves on which the new estimate is based show by their wide range of discrepancy the unsatisfactory nature of the method of observation relied upon by Sir G. Airy. The combinations for ingress, which ought to agree closely with the observations for egress, differ from them by 0″.108, corresponding to a difference of about 1,100,000 miles in the estimated distance of the sun. Yet we are gravely assured that results differing thus widely *inter se* give a mean value which can be trusted as correct within 200,000 miles. In other words we are to regard Newcomb's distance based on twenty times as many observations by six better methods, as probably a million miles too small, and almost certainly 800,000 miles too small, on the strength of observations, divisible into two sections, whereof one gives a result more than a million miles greater than the result given by the other. It is altogether unlikely that astronomers will accept a conclusion of this kind.

Observations of Mars.—Very interesting spectroscopic observations of Mars have been made at Greenwich during the recent opposition approach, and also many valuable telescopic observations at Madeira by Mr. N. E. Green. The spectrum of Mars was compared with that of the moon on August 23 and September 26, when their altitudes were nearly equal. Several faint diffused bands (besides, of course, the dark Fraunhofer lines) were observed in the spectrum of Mars on both occasions, of which only the three strongest could be seen in the spectrum of the moon. "On September 12," says the report communicated by the Astronomer Royal, "when the large spot, called in Proctor's chart 'Dawes' Ocean,' occupied the centre of the disc, the spectrum of Mars was examined for the detection of local differences. The dark spot gave a much fainter spectrum than the rest of the disc, the con-

trast being very marked in the red and yellow, and less so in the violet; it showed, however, no lines or bands other than those seen in other parts. The spectrum of the polar spot and its neighbourhood were very bright from about D to F, but showed very little red; the north limb, on the contrary, gave a spectrum somewhat less bright in the green and yellow, but extending further into the red. The group round C seemed to be darker over 'Dawes' Continent' (the bright spot north of 'Dawes' Ocean') and less dark on the north limb. Bands *a* and B were seen, but no difference in their appearance from whatever part of the disc was examined; but being fainter than C, a slight difference was less likely to be detected." "On September 21 and 26, the absorption bands then measured were noticed to be very slightly fainter in the limb than anywhere else. The locality where they were most distinct was variously estimated as from 5″ to 6″ from the limb on September 21, and from 3″ to 4″ on September 26; as the definition was much better on the latter occasion the smaller estimation is more likely to be correct. The difference in intensity, except just on the limb, was exceedingly slight; but the point where the bands were estimated to be darkest was always found to be at the same distance from the limb." This points unmistakably, as it seems to us, to the conclusion that the whiteness near the limb results from the condensation of aqueous vapour into the form of visible cloud. "The red end of the spectrum of Mars was much fainter on or near the limb; but the violet seemed of the same intensity from all parts of the disc, and was visible about as far as in the spectrum of the moon. The observations were made by Mr. Maunder."

Mr. Green's drawings of Mars must be regarded as taking the place which has heretofore been accorded to Mr. Dawes' drawings of the planet. They certainly far surpass all yet taken in accuracy as well as in fulness of detail. He used a 13-inch silver-on-glass reflector, by With, and a fine 12½-inch speculum, by Messrs. Horne & Thornthwaite. Each drawing was made direct from the telescope, and entirely independent of those which had been produced previously, all comparison being reserved till the evening was over. In one region (that lying east of the De la Rue Ocean, in Proctor's chart—see our number for July, 1877) several important corrections have been made. In particular, the sea to which Mr. Proctor gave the name of Lockyer Sea, is shown to be far more strongly marked than the one to the north, called Dawes Sea. The narrow inlet connecting Lockyer Sea with De la Rue Ocean in Mr. Dawes' drawings has no real existence. Under unfavourable atmospheric conditions there appears to be an inlet; but when the definition is good the appearance is found to be due to the presence of a small lake lying in the line of the supposed connection.

"It has been remarked," says Mr. Green, "that the snow caps do not agree exactly with the poles of the axis of revolution. It may be a confirmation of this statement to mention that by September 18, the snow zone," which a week before had appeared large and distinct, "was considerably reduced in size, and its outline very indefinite, whereas by the end of the month it had returned in great measure to its previous form and size; the rapidity and extent of this change being greater than could be attributed to simple alterations of temperature."

An amusing episode occurred after the reading of Mr. Green's paper at the

Astronomical Society, a foolish person starting the theory that the ruddy colour of Mars is due to heat, or rust, we forget at the moment which. The dignity with which the President explained that, owing to the lateness of the hour the theory need not be discussed, was delightful to all save the theorist, who did not appreciate, perhaps did not fully understand the joke.

The Satellite of Neptune seen with a 4½-inch Object-glass.—Mr. J. W. Ward, of Belfast, whose observations of the two outer satellites of Uranus with a 4½-inch achromatic, excited considerable attention in the spring of 1876, has achieved what might be supposed the still more surprising feat of observing the satellite of Neptune with the same telescope. It appears, however, that he finds the satellite of Neptune as easy to see, or rather he finds it not more difficult to see, than the two outer satellites of Uranus, whence we must infer that Neptune's satellite is a far larger body than any of the satellites of Uranus.

Lunar Inequalities.—Mr. Neison writes to us as follows:

"Sir,—In the October number of the 'Popular Science Review' I find a statement about myself which is entirely untrue, and which, therefore, I beg of you to be so good as to give me the opportunity of contradicting in the next number of the 'Review.' These statements had been already made in another periodical and denied by me, and I refer you to the enclosed copy of the November number of the "Astronomical Register" for a detailed proof that they are perfectly unfounded.—Yours faithfully, E. Neison."

Our remarks were very moderate, the strongest words we used being in a sentence to the effect that Mr. Neison's procedure seemed to us ill-considered. We brought no "railing accusation" against him. It is in his power, we have no doubt, to remedy the mistake so far as it affects himself by original research.

Proper Motions and Distances of the Fixed Stars.—M. Flammarion who has lately achieved notoriety by his new chart of Mars based on M. Terby's researches, announces two sets of results of what he describes as his original researches into sidereal astronomy. In the first place, by charting the proper motions of the fixed stars, he finds reason to believe that some of these bodies are travelling together through space. In the second place, he says, after describing the theories of Sir W. Herschel, Struve, and others, 'les recherches que j'ai entreprises m'ont lentement et successivement amené à des conclusions toutes différentes, dont voici le résumé. Les plus grandes différences d'éclat intrinsèque, de dimensions, et de masses, existent entre les étoiles. Il y a peut-être autant de différences entre les étoiles qu'entre les planètes de notre système. Ainsi la distribution générale des étoiles n'offre pas la régularité classique sous laquelle on l'envisageait; de petites étoiles, des amas, et des nébuleuses, peuvent être moins éloignés de nous que des étoiles brillantes; et la constitution des cieux présente un caractère moins simple que celui qui lui était assigné par des jauges télescopiques et la théorie d'une distribution homogène.' The following passages in an essay by Mr. Proctor would therefore seem to be plagiarisms of M. Flammarion's later views on these points:—"The charting of the stellar proper motions has led me to the discovery of the fact that the stars in many parts of the heavens are travelling in systems—or, as it were, drifting—through space" . . . instances cited . . . "The general conclusions to which I

have been led by these and other methods of research are chiefly these: The sidereal system is altogether more complicated, altogether more varied in structure than has hitherto been supposed. Within one and the same region co-exist stars of many orders of real magnitude . . . All the nebulæ hitherto discovered exist within the limits of the sidereal system." And so forth. Mr. Proctor's offence is not one of yesterday. The paper from which we have quoted appeared in the "Quarterly Journal of Science" for July 1872; but since August 1867 (*see* "Intellectual Observer" for that date) Mr. Proctor has been thus unfairly describing as his, results which were in reality promulgated by M. Flammarion in 1877. Nay, some were announced even earlier by M. Flammarion. For instance, in 1870 Mr. Proctor described the drift of five stars of the seven forming "the Plough." Now as far back as 1873 this had been described by M. Flammarion in an article entitled "The future of a constellation." M. Flammarion seems to think not "Pereant qui, &c.," but "Periêrunt qui ante nos nostra dixerint."

De Vico's Comet.—This comet of short period should have returned to perihelion this year according to the calculations of Professor Brünnow. As it has not been seen, Mr. Hind considers that "we must probably place the comet in the class which though undoubtedly moving in elliptical orbits of small dimensions when under observation, are now 'lost.'" "But whether this arises from a larger error in the determination of the mean motion in 1844 than at present appears admissible, or whether the action of the planet Mars may explain it, or, again, whether the comet has encountered one of the minor planets, and thereby been deflected or disintegrated, cannot be at present ascertained."

Phenomena for the Quarter.—Venus will be at her greatest brilliancy as an evening star on January 16, in inferior conjunction with the sun at 5 a.m. February 21, and at her greatest brilliancy as a morning star on March 29. The disappearance and reappearance of Saturn's rings on February 6 and March 1 respectively, will not be observable, owing to Saturn's proximity to the sun, Saturn being in conjunction with the sun on March 13 at 6 p.m. On February 16, at 5 a.m., Uranus will be in opposition. Neither the solar eclipse of February 1, nor the lunar eclipse of February 16, will be visible in this country.

BOTANY.

Germination of Megarrhiza californica.—Dr. Asa Gray finds that the germination of this cucurbitaceous plant, which is allied to *Echinocystis*, presents certain peculiarities which he describes ("Silliman's Journal," July 1877). The seeds came up in the manner of beans, the body of the seed in its shell being raised well out of the soil upon what seemed to be a well-developed radicle, like that of *Echinocystis*, but no plumule made its appearance from between the fleshy cotyledons. On the contrary, in about a fortnight, in all three of Dr. Gray's young plants, the plumule pushed separately out of the soil of the pot, and, on the whole plant being exposed, it was found to spring from the base of what appeared to be an elongated radicle (two or three inches long), and below it the thickening of the root, which is a

striking character of the species of *Megarrhiza*, had already made considerable progress. The plumule issued from a cleft at the base of the seeming radicle, through which a considerable amount of the nutriment stored in the cotyledons must have been carried down to assist the growth of the root and plumule. From further investigation it appeared that the supposed radicle was really formed by two connate petioles of the cotyledons, not present in the seed.

CHEMISTRY.

Liquefaction of Nitric Oxide, Marsh Gas, and Oxygen.—The close of last year will be remembered as the occasion of the announcement of two important discoveries in physical chemistry. Cailletet has succeeded in liquefying nitric oxide. This gas which, it had previously been found, would not change its state of aggregation if cooled to −110° C. or subjected to a pressure of 50 atmospheres ("Compt. rend." 1877, p. 1016), becomes liquid under a pressure of 104 atmospheres at −11° C. He finds, moreover, that at 8° C. the dioxide remains gaseous under pressures equal to 270 atmospheres. Berthelot submitted some gases to a pressure of 800 atmospheres without inducing a change. The cause of this has been explained by Andrews, who has traced the connection which exists between the properties of a so-called permanent gas and those of liquids which condense almost without change of volume. He finds that for each vapour there exists a critical point of temperature, above which the vapour cannot be converted into a liquid by any pressure however great it may be. Cailletet also communicates some interesting results of experiments made for the purpose of liquefying marsh gas. He noticed that at a temperature of 7° C. and under a pressure of 180 atmospheres the gas under examination becomes *cloudy* and exhibits the same appearance as has been observed in the case of liquid carbonic acid when the pressure has been suddenly reduced. There appears little doubt that this was condensed marsh gas, which rapidly evaporated when it came in contact with the glass and mercury of the apparatus. It is not at all improbable, therefore, that Cailletet will before long succeed in removing light carburetted hydrogen from the list of permanent gases. The "Journal de Genève" of the 23rd December (see the "Times," 26th December, 1877), announces the liquefaction of oxygen by Raoul Pictet. The process adopted appears, from the short extract referred to, to have consisted in subjecting the gas to great pressure and a low temperature produced by the evaporation of solid carbonic acid. The latter gas was first liquefied at a temperature of −65° C. and under a pressure of from four to six atmospheres by the aid of sulphurous acid. The carbonic acid was then placed in a long tube connected with two pumps acting together, and the exhaustion continued till the acid became solid. Through this tube containing the frozen gas, passed another of very fine bore, along which a current of oxygen, prepared from potassium chlorate, was conveyed. The pressures to which the oxygen could be subjected reached as high as 800 atmospheres. At a pressure, however, which it is stated did not exceed 300 atmospheres, the gas was liquefied, and a jet of liquid oxygen was projected from the extremity of the fine tube at

the instant that the compressed and cooled gas exchanged the intense pressure for that of the atmosphere.

Plant Chemistry.—Professor Church has examined colein, the red colouring matter of *Coleus Verschaffeltii*, and is inclined to think that it is identical with œnolin, obtained from red wine, as well as with the substances anthocyan, erythrophyll and cyanin, which have been extracted from blue and purple flowers. Colein is soluble in alcohol, but insoluble in ether; acids turn its solutions red, while alkalies strike a violet, indigo-blue, green, and, finally, yellow colour. The formula of colein is $C_{10}H_{10}O_5$; the salts which it forms with lead, barium, and other metals, have been prepared. It appears to be present in the copper-beech and the grape, and it is perfectly distinct in its characters from the colouring-matter of the red beet. The composition of the flowers of *Fraxinus excelsior* has also been investigated by Professor Church. He found the ash to contain 39·42 per cent. of potash, 13·22 per cent. of lime, and 28·98 per cent. of phosphoric acid. The ash-flowers contain 7·4 times as much nitrogen, 7·7 times as much potash, and 10·5 times as much phosphoric acid as has been found in the leaf-scales of the beech. His paper ("Journal of Botany," 1877, vi. 346) contains, moreover, some interesting observations on the composition of the leaves of a variegated form of *Acer Negundo*. The ash of the white and green portions were analysed separately with the following results:—

Percentage in Ash of	White Parts.	Green Parts.
Potash	40·05	12·61
Lime	10·89	39·93
Magnesia	3·96	4·75
Phosphoric Acid	14·55	8·80

These figures seem to show that the white leaves, or parts of leaves, of this maple differ from the green leaves much in the same way that young leaves differ from old.

The Behaviour of Sulphates with Melted Sulphur.—Sestini has shown that gypsum when heated with sulphur decomposes in accordance with the equation:—

$$CaSO_4 + 2S = 2SO_2 + CaS.$$

Violi has since observed that this reaction appears to be a general reaction as regards the sulphates. Sulphates of the metals of the alkaline earths, as well as those of aluminium, chromium, zinc, manganese, iron, cadmium, lead, bismuth, copper, antimony, and mercury, are converted into sulphides in accordance with the equation, $RSO_4 + 2S = RS + 2SO_2$. The author recommends this method for the formation of a metallic sulphide, and also as a source of sulphurous acid (*Ber. Deut. Chem. Gesell.*, x. 293).

Preparation of Nitrogen.—It has been observed by Gatehouse ("Chemical News," xxxv. 118) that ammonium nitrate and manganese peroxide, when heated together at a temperature of 165°–200° C., evolve a constant current of an invisible gas, which neither burns nor is absorbed by potash pyrogallate. The gas proves to be pure nitrogen, formed in accordance with the equation:—

$$4NH_4NO_3 + MnO_2 = Mn(NO_3)_2 + 8H_2O + 6N.$$

320 grammes of ammonium nitrate gave 67·14 litres of nitrogen, at the normal temperature and pressure. In one experiment where 3 grammes of nitrate were heated with the requisite amount of manganese peroxide in a mercury bath at 205° C., they yielded 606 cub. cent. of nitrogen; the theoretical amount is 630 cub. cent. At higher temperatures than 215° C. the reaction appears to be a complex one, the manganese nitrate being broken up into manganese oxide, hyponitric acid, and oxygen.

The Estimation of Nickel.—A paper on this process, written by Margaret S. Cheney, and Ellen Swallow Richards, and dated from the "Women's Laboratory, Massachusetts' Institute of Technology," appears in the "Amer. Journ. Sci.," 1877, xiv. p. 178. The authors having occasion to determine quantitatively the amount of nickel in some pyrrhotites and matts were led to examine the accuracy of the various methods proposed for the separation of that metal from iron. They found that which is known as the acetate process to be a tedious one, and the plan for the removal of the iron with ammonium hydrate very unsatisfactory: but good results were obtained by the process proposed by Field in 1859, who employed lead oxide to effect the complete separation of the metals. In the case of the nickel, which they weighed as oxide, the analytical numbers were too high—a result which was to be expected; and they were finally led to adopt a process based on the fact that nickel phosphate is completely soluble, while iron phosphate is almost insoluble, in acetic acid, in presence of an excess of sodium phosphate. After the metals which are thrown down by sulphuretted hydrogen have been removed, and the filtrate has been boiled to drive off the excess of that reagent, the iron is oxidized with nitric acid, and ammonium hydrate is added until a permanent precipitate begins to form, but not until complete precipitation of the iron oxide is effected. Acetic acid is then added to re-dissolve the oxide, and the deep-red coloured solution raised to the boiling point. An excess of ordinary sodium phosphate is then added to it, and the nearly white precipitate is filtered off and washed with hot water containing acetic acid. The filtrate is heated nearly to the boiling point, and caustic potash is added to it till the odour of ammonia is distinctly perceptible. The apple-green precipitate of nickel phosphate is partially washed, dissolved in a little *dilute* sulphuric acid, the solution rendered strongly alkaline with ammonium hydrate, and the nickel precipitated with the battery; a current from two quart cells charged with bichromate and sulphuric acid sufficed in two hours to completely precipitate the metal. The numbers fall only a little short of those required by theory, amounting in three experimental determinations to 99·06, 99·33, and 99·73 per cent. respectively.

Absorption of Carbonic Oxide.—Böttinger finds that carbonic oxide, when conducted through hydrocyanic acid cooled to a low temperature, is abundantly absorbed by that liquid; if concentrated hydrochloric acid be added to the solution, the two liquids will not mix. When the vessel containing them is removed from the freezing mixture, a constant current of pure carbonic oxide is evolved; on the subsequent application of heat the evolution of gas becomes stronger, while the gas itself is contaminated with hydrocyanic acid; finally the liquids mix and a turbulent disengagement of gas is the result, pure unaltered hydrocyanic acid remaining in the vessel.—*Ber. Deut. Chem. Gesell.*, 1877, x. 1122.

Synthesis of Hydrocarbons.—Friedel and Crafts have recently published a valuable series of papers on a new method, of general application, for the synthesis of hydrocarbons, acetones, &c. ("Journ. Prakt. Chem.," 1877, xvi. p. 233.) The chemical changes are brought about by the action of aluminium chloride. When to amylic chloride dissolved in benzol some of the metallic chloride is added, hydrochloric acid is set free, and amyl-benzol is formed:—

$$C_5 H_{11} Cl + C_6 H_6 = H Cl + C_6 H_5 (C_5 H_{11}).$$

If an organic bromide or iodide be taken in place of a chloride, a similar reaction is noticed: ethylic iodide, for example, in the presence of benzol and the metallic chloride forms hydriodic acid and ethyl-benzol:

$$C_2 H_5 I + C_6 H_6 = H I + C_6 H_5 (C_2 H_5).$$

Methylic chloride dissolved in benzol under similar conditions produces toluol; and when two, three, or four molecules of methylic chloride react on one molecule of benzol in presence of aluminium chloride, xylol, mesitylen and durol are produced, a corresponding number of molecules of hydrochloric acid being set free. Under similar circumstances benzylic chloride yields diphenylmethane. Bodies containing more than one atom of chlorine are also acted upon in a like sense when in contact with benzol and the metallic chloride; chloroform produces triphenylmethane, and carbon tetrachloride tetraphenylmethane. Benzoic and acetic chloride form respectively benzophenon and acetophenon. Other metallic chlorides resemble that of aluminium in their ability to withdraw hydrochloric acid; iron perchloride acts at ordinary temperatures, and iron protochloride when heat is applied. The authors are of opinion that in the first stage of the reaction, which we have considered, an organic compound containing aluminium is formed, which then undergoes decomposition, setting the aluminium chloride once more free. The case where benzylic chloride enters into the reaction, for example, would be represented thus:—

$$C_6 H_6 + Al_2 Cl_6 = H Cl + \underbrace{Al_2 Cl_5, C_6 H_5}_{\text{hypothetical compound.}}$$

$$Al_2 Cl_5 (C_6 H_5) + (C H_2 C_6 H_5) Cl = Al_2 Cl_6 + \underbrace{(C H_2 C_6 H_5) C_6 H_5}_{\text{Diphenylmethane.}}$$

Phosphorescence of the Salts of Quinine.—It has been noticed by Landerer ("Ard. Pharm.," [3] x. p. 322) that quinine sulphate becomes phosphorescent at 40° to 50° R. If some of the salt, strewn over a sheet of smooth paper, be placed on a plate of metal and exposed to this temperature, it becomes beautifully phosphorescent when stirred with a glass rod, the light being observed for some minutes. Valerate of quinine exhibits the same phenomenon, even when heat is not applied; if a few crystals be rubbed or struck in a mortar a luminous appearance is observed with each blow of the pestle. The phenomenon, it seems, is only noticed when use is made of valerate containing acid which has been prepared directly from the root of the valerian.

Polyporic Acid.—This acid has been obtained by Stahlschmidt from several species of *Polyporus* ("Annalen der Chemie," 1877, clxxxvii. p. 177).

It appears to be quite insoluble in water, so that the addition of a few drops of a mineral acid to an aqueous solution of the merest trace of a polyporate causes the liquid to become turbid; it is proposed to make use of this delicate reaction in alkalimetry in place of a colour test. The salts of the acid are well-defined compounds, some of which, as the polyporates of potash, soda, and ammonia, form deep purple-coloured solutions. The empirical formula of polyporic acid appears to be $C_7 H_3 O_2$. When the potash salt is heated to redness with zinc-powder, benzol is formed.

Platinum Black.—A ready method of preparing the metal in a form which exhibits unusually active catalytic properties has been described by Böttger ("Pharm. Centralbl.," xviii. p. 218). He adds to a solution of platinic chloride sufficient seignette salt (potassium sodium tartrate), and heats the mixture to the boiling point; a brisk evolution of carbonic acid takes place, and in a very short time all the metal separates from the solution; it has then to be washed and dried at a moderate temperature. The finely-divided metal prepared in this way readily converts alcohol into acetic acid, and ignites illuminating gas when placed in contact with gun-cotton.

GEOLOGY.

A New Order of Fossil Reptiles.—The researches of American explorers in that apparently inexhaustible mine of palæontological novelties, the Far West, have furnished Professor Marsh with a great portion of the skeleton of a huge reptile, which he regards as one of the most remarkable animals yet discovered. It was obtained on the eastern flank of the Rocky Mountains, in beds which may be regarded as nearly corresponding to the Wealden or else as Upper Jurassic. The animal, which Professor Marsh denominates *Stegosaurus armatus*, probably measured about thirty feet in length, and moved mainly by swimming. It possessed teeth with compressed crowns, inserted in sockets, and measuring nearly four-and-a-half inches in length and nearly an inch in greatest diameter. Besides these there are numerous cylindrical tooth-like organs, about three inches long and three-fifths of an inch in diameter, which were placed in rows, either in thin plates of imperfect bone or in cartilage. These, the author thinks, may prove to be dermal spines with the characters of teeth, such as occur in some fishes. The body was long and protected by bony plates, which appear to have been in part supported by the elongated spines of the vertebræ, which are co-ossified with the biconcave centra. One of the dermal plates was more than three feet long. Professor Marsh regards this remarkable reptile as the type of a new order, which he names *Stegosauria.*—*Amer. Journ. of Sci.*, Dec. 1877.

New American Jurassic Dinosaurs.—The Dinosaur described by Professor Marsh under the name of *Titanosaurus montanus*, as from the Cretaceous deposits of Colorado (see "Pop. Sci. Rev.," Oct. 1877, p. 424), is now found to belong to a lower geological horizon, and is really from the Upper Jurassic. Professor Marsh now changes its name from *Titanosaurus* to *Atlantosaurus*, the former being preoccupied, and states that additional remains which have been obtained, show that it is the type of a distinct family, which he calls *Atlantosauridæ*. The femur of *Atlantosaurus montanus* is about seven

feet long, so that if the animal had the proportions of a Crocodile it was at least eighty feet in length. Two nearly allied species, also with large pneumatic cavities in the centra of the vertebræ, form the new genus *Apatosaurus*; one of them, *A. ajax*, is supposed to have been between fifty and sixty feet, and the other, *A. grandis*, at least thirty feet long. The femur of the latter measures about three feet four inches. These are from a somewhat lower horizon than the *Atlantosaurus*. *Allosaurus fragilis* is a third new species, also with deeply excavated vertebral centra, which are biconcave. The bones of the feet are very slender. The animal, which is from the same locality as the preceding, was from fifteen to twenty feet in length. With these are the remains of a small Dinosaur, about as large as a Fox, described by Professor Marsh as *Nanosaurus rex*.—*Amer. Journ. Sci.*, Dec. 1877.

A Fossil Branchipus.—Mr. Henry Woodward has detected in some Eocene freshwater limestones from Gurnet Bay, Isle of Wight, numerous remains of delicate little Crustaceans of the genus *Branchipus* or *Chirocephalus*. The animals are beautifully preserved, the males exhibiting their large clasping antennæ, and the females their egg-pouches. Mr. Woodward names this interesting little Crustacean, the first of its kind that has undoubtedly been found fossil, *Branchipodites vectensis*. The Branchipods are accompanied in the deposit by two species of Isopod Crustaceans, by several bivalved Entomostraca, and by a great number of the remains of insects belonging to nearly all orders.—*Proc. Geol. Soc.* Dec. 19, 1877.

Fossil Plants from Grinnell Land.—Near Discovery Harbour, where H.M.S. *Discovery* wintered in 1875-6, in about 80° 45′ N. lat., and 64° 45′ W. long., a bed of lignite, from 25 to 30 feet thick, was found, resting unconformably upon the azoic schists of which Grinnell Land chiefly consists. The lignite was overlain by black shales and sandstones, the former containing many remains of plants; and above these there were, here and there, beds of fine mud and glacial drift, containing shells of marine Mollusca of species now living in the adjacent sea. This glacial marine deposit occurs up to levels of 1,000 feet, indicating a depression and subsequent elevation of the region to at least this extent. Of the remains of 25 species of plants collected by Captain Feilden, and submitted by him to Professor Oswald Heer, 18 are already known from Miocene deposits of the Arctic zone. The deposit is therefore no doubt Miocene. It has 17 species in common with Spitzbergen (78° 79′ N. lat.), and 8 species in common with Greenland (70° 71′ N. lat.). With the Miocene flora of Europe it has 6 species in common; with that of America (Alaska and Canada) 4; with that of Asia (Sachalien) 4 also. The species found include 2 species of *Equisetum*, 10 Coniferæ, *Phragmites œningensis*, *Carex nourseakensis*, and 1 Dicotelydons, namely, *Populus arctica*, *Betula prisca* and *Brongniarti*, *Corylus Macquarrii* and *insignis*, *Ulmus borealis*, *Viburnum Nordenskiöldi*, and *Nymphæa arctica*.

Of the Conifers, *Torellia rigida*, previously known only by a few fragments from Spitzbergen, is very abundant, and its remains show it to have been allied to the Jurassic genera *Phœnicopsis* and *Baiera*, the former in its turn related to the Carboniferous *Cordaites*, and among recent Conifers, to *Podocarpus*. Other Conifers are *Thuites Ehrenswardi*?, *Taxodium distichum*

miocenum (with male flowers), *Pinus Feildeniana* (a new species allied to *P. Strobus*), *Pinus polaris*, *P. abies* (twigs covered with leaves), a species of *Tsuga* (*Pinus Dicksoniana*, Heer.), and a white Spruce of the group of *Pinus grandis* and *cariocarpa*. *Pinus abies*, which occurs here and in Spitzbergen, did not exist in Europe in Miocene times, but had its original home in the extreme north, and thence extended southwards; it is met with in the Norfolk forest-bed, and in the interglacial lignites of Switzerland. Its present northern limit is 69½° N., and it spreads over 25° of latitude. *Taxodium distichum*, on the contrary, spread in Miocene times from Central Italy to 82° N. latitude, whilst at present it is confined to a small area.

Betula Brongniarti, Ett., is the only European species from Grinnell Land not previously known from the arctic zone.

The thick lignite-bed of Grinnell Land indicates a large peat-moss, probably containing a lake in which the water-lilies grew; on its muddy shores stood the large reeds and sedges, the birches, poplars, *Taxodia*, and *Torelliæ*. The drier spots and neighbouring chains of hills were probably occupied by the pines and firs, associated with elms and hazel-bushes. A single elytron of a beetle (*Carabites Feildenianus*) is at present the sole evidence of the existence of animals in this forest region.

The nature of the flora revealed by Captain Feilden's discoveries seems to confirm and extend earlier results. It approaches much more closely to that of Spitzbergen than to that of Greenland, as might be expected from the relative positions of the localities; and the difference is the same in kind as that already indicated by Professor Heer between Spitzbergen and Greenland, and would indicate the same kind of climatic difference. Nevertheless, the presence of *Taxodium distichum* excludes arctic conditions, and that of the water-lily indicates the existence of fresh water, which must have remained open a great part of the year. Representatives of plants now living exclusively in the arctic zone are wanting in the Grinnell Land deposits; but, on the other hand, most of the genera still extend into that zone, although they range in Grinnell Land from 12° to 15° further north than at present.—*Proc. Geol. Soc.*, 7th November, 1877.

European Tertiary Deer.—In a paper lately read before the Geological Society, Professor W. Boyd Dawkins discussed the characters presented by the European Miocene and Pliocene Deer, and indicated that the majority of the known antlers may be referred to two categories—an earlier or Capreoline, and a later or Axidine type. To the CAPREOLI he referred the following species:—*Dicroceros elegans*, Lart., = *Prox furcatus*, Hemel, *Cervus dicranoceros*, Kaup. (including *C. anoceros* and *trigonoceros*, Kaup.), and *Cervus Matheronis*, Gerv. (= *C. Bravardi*) from the Miocene, and *Cervus australis*, Gerv., and *C. cusanus*, Croizet & Jobert, from the Pliocene. To the AXEIDES belong *Cervus Perrieri*, Cr. & Job. (including *C. issiodorensis* and *pardinensis*, of the same authors), *C. etueriarum*, Cr. & Job. (= *C. rusoides*, Pom., and *C. perollensis* and *stylodus*, Brav.), *C. suttonensis* sp. n., and *C. cylindroceros* Brav. (including *C. gracilis*, Brav.), all from Pliocene deposits. Besides these, the author noticed a species *incertæ sedis* under the name of *Cervus tetraceros*, Dawkins, which he regards as coming nearest to the Virginian Deer, or Cariacou (*Cariacus virginianus*). From the examination of the antlers of these species he indicates that in the Middle Miocene

age the cervine antler consisted of a simply forked crown, whilst in the Upper Miocene it became more complex, although still small and erect, like that of the Roe Deer. In the Pliocene it becomes larger and more complex, some forms, such as the *Cervus dicranios*, Nesti, being the most complicated of known antlers. The successive changes are analogous to those observed in the development of the antlers of the living deer with increase of age. In the Miocene we have the zero of antler-development, and the Capreoline type is older than any other. The nearest living analogue of the Miocene Deer is, according to the author, the Muntjak (*Styloceros*), now found only in the oriental region of Asia, along with the Tapir, which also coexisted with *Cervus dicranoceros* in the Miocene forests of Germany. The Pliocene Deer, again, are generally most nearly allied to the oriental Axis and Rusa Deer, the only exception being *Cervus cusanus*, the antlers of which resemble those of the roe, an animal widely spread over Europe, and Northern and Central Asia. The alliance of these Pliocene Deer with those now living in the Indian region is regarded by the author as a further proof of the warm climate of Europe in Miocene times, confirmatory of the conclusions arrived at by Saporta from the study of the vegetation.

A New Bird from the London Clay.—Professor Owen has recently described before the Geological Society some remains of a large bird obtained by Mr. W. H. Shrubsole from the London Clay of Sheppey, consisting of parts of fractured humeri, belonging to the right and left side of the same species or perhaps individual, and including the head of the bone, with portions of the upper and lower parts of the shaft. The texture of the shaft, the thinness of its bony wall, and the large size of the cavity recall the characters of the wing-bones of the large Cretaceous Pterodactyles. The author indicated the characters which led him to regard the remains under consideration as those of a volant bird, most nearly approaching the genera *Pelecanus* and *Diomedea*; and as the evidence derived from the cranium of *Dasornis* would indicate a bird too large to be upborne by wings to which these bones might have belonged, whilst the skull of *Odontopteryx* is far too small to have formed part of a bird with wings as large as those of the Albatross, and *Lithornis* and *Pelargornis* are excluded by the characters of their remains, the author concluded that the bones obtained by Mr. Shrubsole furnished indications of a new genus and species of flying birds, for which he proposed the name of *Argillornis longipennis*. He regarded it as probably a long-winged natatorial bird, most nearly related to *Diomedea*, but considerably exceeding the Albatross (*D. exulans*) in size.—*Proc. Geol. Soc.*, 19 Dec. 1877.

A Fossil Fungus.—Mr. Worthington G. Smith has given a long description, with figures ("Gardener's Chronicle," 1877, p. 499) of what appears to be a parasitic fungus allied to *Peronospora*, found traversing the scalariform axis of a *Lepidodendron*. The mycelium is formed by slender threads with numerous joints or septa, and bears upon short branches a considerable number of spherical oogonia or zoosporangia, within many of which the zoospores can be clearly distinguished. Singularly enough, both the oogonia and their contained zoospores are of precisely the same size as the corresponding organs in the existing *Peronospora infestans*, the fungus of diseased

potatoes. For this parasite Mr. Smith proposes the name of *Peronosporites antiquarius*.* *Peronospora* is one of those low forms, the true position of which is exceedingly doubtful. If not an Alga, it is exceedingly nearly related to the Algæ, and we may remind our readers that some two years ago Professor Duncan described before the Geological Society ("Quarterly Journal of the Geological Society," vol. xxxii., p. 205) the occurrence in fossil shells and corals even as low down in the series of formations as the Silurians, of parasitic mycelia bearing sporangia, very similar in many respects to the organisms described by Mr. Smith. He regarded these filamentous plants as Algæ, nearly related to the existing genus *Achlya*, and named the species, *Palæachlya perforans*. Mr. Carruthers, at a still earlier period ("Quarterly Journal of the Geological Society," vol. xxvi., p. 351) noticed the occurrence of mycelial threads, which he referred to *Peronospora*, among the cells of his *Osmundites Dowkeri*, an Eocene fossil fern from Herne Bay. References to previous observers of similar perforant organisms in recent and fossil shells, and other hard parts of animals, will be found in Professor Duncan's paper above referred to. Professor Kölliker regarded the parasites observed by him in recent shells as Fungi.

METEOROLOGY.

A Third Diurnal Barometric Maximum in Winter.—M. Rykatchev announces ("Bull. Acad. Sci. de St. Petersb.," tome xxiv., No. 1, p. 108) that throughout the temperate zone of the northern hemisphere the barometer in winter, and especially in the month of January, shows a third maximum, or at least a greater or less rise between one and two o'clock in the morning. He gives a table showing the diurnal course of the barometer at numerous stations in Europe, Asia, and North America, in support of his statement. His third maximum is greatest between latitudes 40° and 45° N.; in the tropics it is not observed. M. Rykatchev takes occasion to point out from the occurrence of this maximum the necessity of day and night observations of the barometer at all stations, seeing that the barometric curves drawn in accordance with Bessels' formula from day observations alone give no indication of it.

MINERALOGY.

Coloradoite.—Closely following on Krenner's announcement of the occurrence of bunsenine (gold telluride) at Nagyág comes the discovery by Genth of a new telluride, to which he has given the above name. ("Amer. Journ. Sci.," 1877, xiv. p. 423). It has been met with in the Keystone and Mountain Lion Mines of Colorado. The new species is not crystallized, and has an iron black colour and metallic lustre; its composition has been found to be

Mercury	60·98
Tellurium	39·02
	100·00

* *Antiquus* would be a better specific name.

which numbers correspond with the formula Hg Te. In the same mine, the Keystone Mine, where this mercury telluride occurs, two more new minerals have been discovered. One, which has been named *magnolite*, is found in bundles or tufts of white silky needles; they appear to have the composition indicated by the formula Hg_2 Te O_4. The second, *ferrotellurite*, forms delicate tufts of minute prismatic crystals of a straw and lemon-yellow colour; their composition is probably represented by the formula Fe Te O_4.

Cassinite.—Genth, in his Report on the Mineralogy of Pennsylvania, states that while the minerals, lenilite and delawarite, which Lea regarded as varieties of orthoclase, are identical with orthoclase, cassinite, on the other hand, which Lea had also included in the same category, proves to be of interest from the fact of its containing 4 per cent. of baryta. The density of cassinite is 2·692, and the analytical results which Genth has published show the oxygen ratios for $(R_2 O + R O) : R_2 O_3 : Si O_2$ to be 1 : 3 : 10.7. His results are of interest when compared with those of Des Cloizeaux on baryta-felspar.—*Zeitschrift für Krystall. und Mineralogie*, 1877, 1298.

Venerite, a New Copper Ore.—This ore occurs in the Jones Mine, near Springfield, Caernarvon Township, Berks County, Pennsylvania, a locality which has long been known for extensive deposits of magnetite, with more or less chalcopyrite, malachiite, and chrysocolla. In one part of the mine Sterry Hunt observed some layers of a green earth-like substance which, during the last few years, has yielded a considerable amount of copper. When dried it has a greenish white colour, and readily crumbles to a powder which, under the microscope, is seen to consist of thin transparent plates mixed with a few quartz grains and some magnetite. Analyses of a pure pecimen gave the following numbers:—

Silicic acid	30·73
Alumina	14·67
Iron peroxide	5·35
Iron protoxide	0·29
Magnesia	18·55
Copper oxide	17·58
Quartz	12·83
	100·00

The oxygen ratios of $R O : R_2 O_3 : Si O_2 : H_2 O$ are 3 : 4 : 6 : 4, from which it appears that the substance, if homogeneous, must be placed among the chlorites.—*Zeitschrift für Krystall. und Mineralogie*, 1877, 495.

Silaonite.—Fernandez and Navia have given this name to a new selenide, which they have found associated with guanajuatite. It occurs massive, has a bluish grey colour, a hardness of $2\frac{3}{4}$, and a density = 6·43—6·45. This new Mexican mineral appears to have the composition indicated by the formula Bi_2 Se. Selenium in small quantities has been found in association with tellurium in the josëite of Brazil.—*Zeitschrift für Krystall. und Mineralogie*, 1877, 499.

Vietinghofite.—Damour has analysed a mineral found by De Lomonossow, on the shores of Lake Baïkal. The new species is without crystalline form, has a dull black colour, a semi-metallic lustre, and a vitreous fracture. Its hardness is 5·5—6·0, and the specific gravity = 5·53. A fragment melts

before the blow-pipe, forming a black non-magnetic mass. The chief constitutents of vietinghofite are: niobic acid, 51·00 per cent.; iron protoxide, 23·00 per cent.; uranium oxide, 8·85 per cent.; yttria, 6·57 per cent.; and manganese protoxide, 2·67 per cent. The new mineral appears therefore, to be a variety of Samarskite.—*Bull. de l'Acad. St. Petersbourg*, xxiii. p. 463.

Touchstone.—Dumas has recently published the results of an analysis of a specimen of touchstone, probably the very specimen examined by Vauquelin. ("Journ. Chim. Pharm.," xxii. p. 426). The silica present amounts to 81·40 per cent. He believes the touchstone to be a variety of fossil wood, a small portion of the woody tissue of which has not been replaced by silica. Certain specimens from the Alps yield on ignition an ash which consists of silica only; they still retain, however, sufficient evidence of structure to allow of the determination of the genus whence they are derived. A microscopic examination of sections of touchstone by Regnault has shown that in some cases the organic matter present consists of a variety of bitumen resulting from the decomposition of the tissues of the original wood; the intense black colour of that substance, as it fills the cell-walls and spaces once occupied by fibrous structure, renders the form and details of the cellular portion apparent.

Meteorites.—Professor Tschermak, of Vienna, has issued a short notice of the important additions made, down to the end of September, 1877, to the collection of meteorites under his care. During the last five years stones from twelve, and irons from eight, new localities have been added. The remaining (fourth) fragment of the giant stone of Knyahinya has been acquired by purchase, and it now weighs, in its entirety, 293 kilog. A large mass of, iron, weighing 198 kilog., from the Bolson de Mapini, Cohahuila, Mexico, has likewise been acquired. The total number of falls now represented is 308; in 1819 the number was 36; in 1843 it rose to 94; in 1859 it was 176, and in 1868 it attained 244. Since 1869 Professor Tschermak has added specimens of 64 falls, previously not represented, to the collection; and the total weight of meteoric matter has during the interval been increased from 570 kilog. to 1025 kilog. The most recent aerolitic showers, of which specimens have been secured, are those which occurred at Iowa City (Amana), Iowa, February 12, 1875; and Zsadany, Temeser Comitat, Hungary, March 31, 1875; and the last new meteoric iron comes from Nenntmannsdorf, Pirna, Saxony, and bears the date 1872.

PHYSICS.

Magnetism of Nickel.—M. H. Wild has investigated the magnetic properties of pure nickel, and comes to the following conclusions. Unlike pure (soft) iron, pure nickel acquires a considerable amount of permanent magnetism, but its maximum is only from one-third to one-half of the permanent magnetism acquired by hard steel, according to the goodness of the latter. The magnetism remaining in nickel after the cessation of the magnetizing influence is less permanent than in well-hardened steel; and the gradual loss of magnetism by lapse of time, as also by warming and cooling, is

comparatively greater in nickel than in hard steel, even when it is brought, like the steel, to a certain state of permanence by repeated heating and cooling. In this condition, the temperature-coefficient of a nickel-magnet is little greater than that of well-hardened steel. The temporary magnetism acquired by pure nickel is about double its permanent magnetic moment, half the temporary magnetism acquired by hard steel, and one-fourth of that of soft iron.—(*Bull. Acad. Sci. de St. Petersb.* tome xxiv., No. 1, p. 1.)

ZOOLOGY.

The Rhinoceroses.—Professor Brandt has communicated to the Academy of Sciences of St. Petersburg a synopsis of the family Rhinocerotidæ. He divides the family into three subfamilies, namely:—

I. *Thysanodontes* or *Hippodontes*, with rudimentary incisors, and molars resembling those of the horse. It includes the single fossil genus *Elasmotherium*.

II. *Aulonodontes*, the typical rhinoceroses, destitute of canines and frequently with rudimentary incisors, furnished with molars with several roots, and with the crowns traversed by rather oblique transverse furrows. These are usually horned, and include the following genera:—

1. Atelodus, Pomel, with the subgenera *Tichorhinus*, Brandt (*antiquitatis* and *Merckii*), *Mesorhinoceros*, Brandt (*leptorhinus*), *Colodus*, Brandt, (*pachygnathus*), and *Colobognathus*, Brandt (*bicornis* and *simus*).
2. Dyhoplus, Brandt (*Schleiermacheri* and [?] *sansaniensis*).
3. Ceratorhinus, Gray (*sumatrensis*, *lasiotis*, and *cucullatus*).
4. Rhinoceros, Gray (*sondaicus*, *unicornis* and *inermis*).
5. Aceratherium, Kaup (*incisivum*, *minutum* and *Goldfussii*).

III. *Palæotheriodontes* with six incisors and two canines in each jaw, and molars like those of the second subfamily. Includes only the fossil genus *Hyracodon*, Leidy.—*Bull. Acad. Sci. de St. Petersb.*, tome xxiv., No. 1, p. 167.

A Zoological Laboratory for the Channel Islands.—We learn that Mr. W. Saville Kent is now endeavouring to establish in Jersey, by the agency of a Limited Liability Company, a Museum and Laboratory of Marine Zoology and Institute of Pisciculture. He proposes to realize in Jersey the advantages at present furnished only by the Neapolitan Marine Aquarium and Zoological Station; and at the same time to supplement the resources of the establishment, and promote the study of the animal inhabitants of the sea, by supplying zoologists in England and elsewhere with specimens of the creatures forming the rich and varied fauna of the shores of the Channel Islands. Scientific pisciculture is also to constitute one of the leading objects of the "Society." Such an undertaking, if it can be carried out, cannot but furnish a new attraction to the numerous visitors to Jersey, and must exercise a beneficial influence on the study of marine natural history in this country, and we most heartily wish it success. Particulars of the proposed undertaking will be found in "Nature" for December 6, 1877.

The Tape-worms of the Shrews.—In the number of this Review for July

1877, p. 324, we gave a brief account of a new form of vesicular parasite (*Staphylocystis biliarius*), detected by M. Villot, adhering to the biliary vessels of *Glomeris*. That gentleman has since described a second species under the name of *Staphylocystis micracanthus*, from its hooklets being smaller than those of the first-named form. The singularity of the habitat of these larval Cestoids is now explained by the discovery made by M. Villot, that they are the scolices of Tænias infesting the intestines of the Shrews, as these small mammals will undoubtedly devour any specimens of *Glomeris* that may fall in their way. According to Dujardin, our common Shrew (*Sarex vulgaris*) harbours a Tape-worm named *Tænia scutigera*, whilst the little Garden Shrew (*Sarex araneus*) isinfested by three forms of these parasites, namely, *Tænia scalaris*, *tiara*, and *pistillum*. M. Villot regards the distinction between *T. scutigera* and *scalaris* as founded in error, and thinks that these two forms constitute probably a single species, which would therefore infest both species of Shrews; of this species his *Staphylocystis biliarius* is probably the scolex. *S. micracanthus* he refers without hesitation in the same capacity to *Tænia pistillum*.

The history of these parasites is therefore as follows, as interpreted by M. Villot:—The adult progrottids, or so-called joints of the full-grown Tape-worm, loaded with their cargo of eggs, issue from the intestine of the Shrew and remain on the damp ground until some wandering *Glomeris*, either by accident or design, takes them into his stomach, probably along with the decayed vegetable matters on which the Myriopod habitually feeds. Once in the stomach of a suitable host, the young embryos of the parasite will make their way into the biliary ducts, which open near the commencement of the animal's intestine, and, travelling along these for some distance by the agency of their stylets, will finally traverse the walls of those vessels to take up their abode in the midst of the fatty tissue. Here they lose their embryonic stylets, which are no longer of service to them, pass to the vesicular state, undergo proliferous multiplication, and become scolices. A Shrew meeting with one of these Myriopods would eat him up without hesitation, and thus introduce into his own stomach perhaps a hundred or more scolices, which would at once attach themselves to the intestine and bud into perfect Tape-worms.—*Comptes rendus*, November 19, 1877.

Purple Oysters.—It appears that last autumn the oysters in the Bay of Arcachon acquired a very remarkable violet colour. M. Descoust finds that this coloration is due to the presence in the oyster-basin of great quantities of a Floridean Seaweed, *Rhytiphlœa tinctoria*, the spores of which are very highly coloured. He finds that the colouring matter of these spores is assimilated by the oysters, and retained by them, more or less modified, in the lobes of the mantle and the branchiæ, and that they cannot get rid of it unless the water of the oyster-parks is sufficiently diluted by rains. He says that last summer, and especially during the months of June, July, and August, the drought was extreme all about the basin of Arcachon; hence the oysters became gorged with the colouring matter, the water of the parks not being sufficiently diluted to dissolve the latter.—*Comptes rendus*, November 19, 1877.

The Great Newfoundland Calamaries.—Prof. Verrill has lately had an opportunity of examining a fine example of one of these gigantic Cepha-

lopods, which enables him to correct some of his previous notions about them. The specimen, which was alive and nearly perfect when found, was cast ashore, after a severe gale, at Catalina, Trinity Bay, Newfoundland, on 24th September last. After being exhibited for two or three days at St. John's, it was sent in brine to New York, and exhibited in a tank full of alcohol at the Aquarium in that city.

Prof. Verrill says ("Amer. Journ. Sci.," November 1877, p. 425): "Although somewhat mutilated, and not in a very good state of preservation when received, it is of great interest, being without doubt the largest and best specimen ever preserved. It proves to be *Architeuthis princeps*, formerly described by me from the jaws alone, in this Journal ('Amer. Journ. Sci.,' vol. ix. p. 181). The jaws agree well in form and colour with the large pair there figured, and are fully equal to them in size, being apparently larger in proportion to the body than in *A. monachus*; so that my estimate of the probable size of the body of the former specimen was much too great. The Catalina specimen when fresh was 9·5 feet from tip of tail to base of arms; circumference of body 7 feet; length of tentacular arms 30 feet; length of longest sessile arms (ventral ones) 11 feet; circumference at base 17 inches; length of upper mandible 5·25 inches; diameter of large suckers 1 inch; diameter of eye-sockets 8 inches. (The eyes were destroyed by the captors.) It agrees in general appearance with *A. monachus*, but the caudal fin is broader, and less acutely pointed; it was 2 feet and 9 inches broad when fresh, and broadly sagittate in form. The rims of the large suckers are white, with very acutely-serrate margins; and the small smooth-rimmed suckers, with their accompanying tubercles, are distantly scattered along most of the inner face of the tentacular arms, the last ones noticed being 19 feet from the tips. The sessile arms present considerable disparity in length and size, the dorsal ones being somewhat shorter and smaller than the others; the serrations are smaller on the inner than on the outer edge of the suckers."—Although Professor Verrill has found himself compelled, on better acquaintance, to reduce considerably the size of his monster (which he formerly thought to be 19 feet long in the body), the measurements here given leave him still a sufficiently formidable "Devil-fish," and it is probably with a view to his suitable appearance in that character that, as we are told by Professor Verrill, the animal has been "prepared" by a taxidermist, "who has inserted two large, round, red eyes close together on the top of the head!"

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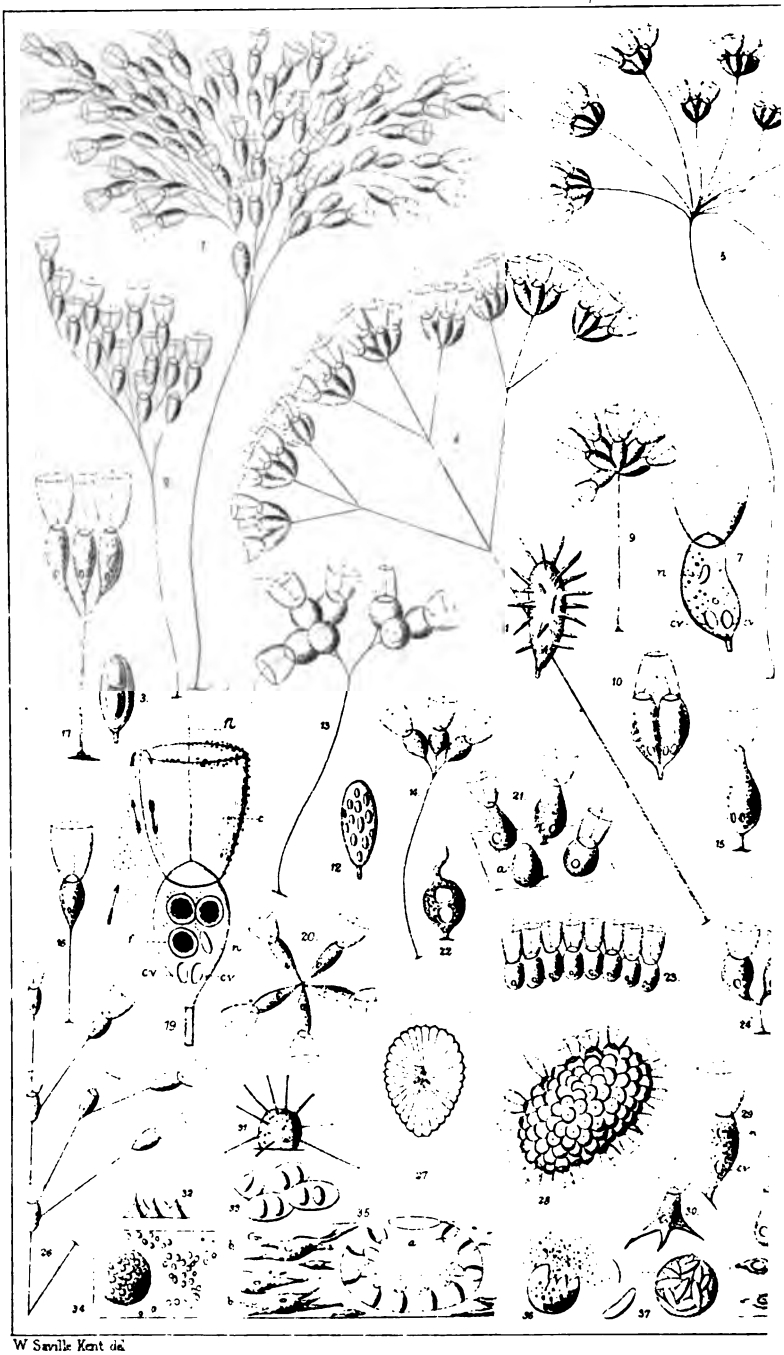

W. Saville Kent del.

Flagellate Protozoa

A NEW FIELD FOR THE MICROSCOPIST.

By W. SAVILLE KENT, F.L.S., F.Z.S., F.R.M.S.

[PLATES III. AND IV.]

IN no department of mechanical science, probably, during the last few years, has the march of progress been productive of more conspicuous and substantial fruits than in that one associated with the construction and perfection of the higher magnifying powers of the compound microscope. It is but a short while, indeed, since an amplification of some 500 linear diameters was about the utmost that could be safely relied upon by the microscopist for the accurate interpretation of independent minute organisms, or for investigating the ultimate structure of more highly complex tissues. Now, however, thanks to the mechanical and scientific skill of both English and foreign manufacturers specially devoted to this branch of optics, our range of vision among the atomic elements of this wondrous world has been extended to an almost incredible degree. A magnifying power of 2,000 or 3,000 diameters is in these days at the disposal of the merest tyro, while Messrs. Powell and Lealand, the opticians of this country to whom the palm of merit for the construction of object-glasses of the highest magnification is almost universally accorded, are able to produce a lens yielding with their deepest eyepiece an amplification of no less than 15,000 linear. To work successfully with a one-fiftieth inch objective and No. 5 eyepiece, the combination giving this marvellous magnification, or indeed to see anything with such a glass, belongs, as might be anticipated, to the professional expert only. A one-sixteenth inch objective, however, capable of yielding the more moderate but still considerably advanced amount of magnification previously named, is at the present date as accessible from a pecuniary point, and after a little practice is as convenient to work with as an ordinary one-quarter inch glass of the best construction.

It would be a matter for congratulation if we could place on record side by side with this attestation to the mechanical perfection and improvements of our magnifying instruments,

evidence of an equivalent amount of progress achieved by microscopic workers in those new fields for investigation thrown open to them by the skill of the optician. With humiliation it is, however, necessary to admit that these new and high-class magnifying powers, distributed as they now are broadcast throughout the land, are destined in the majority of instances to fulfil a most unimportant if not ignoble *rôle*. Boxed up in the cabinet of their possessor, they rarely see the light, except, maybe, for the purpose of a more often than otherwise abortive attempt to resolve the dots or striæ upon the siliceous shell of some obscure and vexatious diatom, further weighted or handicapped in many instances by immersion in a medium intentionally employed for the purpose of rendering previous obscurity still more obscure; or again, perhaps, for an exposition of the owner's views of the nature of the markings upon a Podura scale, or for an attempted solution of some occult question of angular aperture. Granted, that the accomplishment of such trivial ends, and the emulation entertained among amateur microscopists to possess a lens that shall outstrip their neighbours' in the perfection of its defining power, has contributed in no small degree towards the highest triumphs of the optician in this department, it is still greatly to be deplored that so much latent power of discovery should thus lie year after year, like the golden talent of tradition, buried in a napkin. Surely, among the myriads of minute organisms at the base of the animal and vegetable worlds, there is room enough and to spare for valuable and even original investigation! Here, indeed, the harvest-field is full to the overflowing, and to any entering upon it in a scientific spirit, possessing ordinary dexterity of manipulation and some rudimentary knowledge of the forms he is likely to encounter, may be promised a reward far more gratifying to himself and more useful to his fellow-workers than he can achieve by a lifetime devoted to the solution of the markings on a frustule of *Surirella gemma* or on the scales of *Lepidocyrtis curvicollis*. 'Il n'est que le premier pas qui coûte' —and here as elsewhere the chief obstacle experienced by the amateur worker, armed with his new high-power objective, and ardent to win his spurs as an original discoverer, is beyond doubt the selection of a subject. In recognition of this difficulty of making a commencement, and also of the assistance and encouragement that may often be derived from the narration of personal experience gained in the striking out of a novel field, a brief account will here be given of some of the results of a rather successful forage or series of forages conducted by the writer during leisure hours within the last few years, in association with certain newly discovered or previously little known Flagellate Protozoa; all these forms again, without exception, requiring for their satisfactory interpretation the employment of those

powerful and high-class magnifying powers referred to in our opening sentence.

It will no doubt be remembered by many readers of this Journal that certain members of the Flagellate Protozoa, embracing several of those free-swimming monads which occur abundantly in fish- and other animal-macerations, have already been brought before their notice.* On this occasion, however, it is proposed to give a brief descriptive outline, with illustrations, of an extensive series of forms that have so far, on account of their exceedingly minute size, altogether evaded the notice of the microscopists of this country, but which at the same time most certainly surpass all previously discovered types equally in the wonderful symmetry of their individual form and in that of their aggregated mode of growth. So long ago as the year 1866 a few stray members of this Flagellate group, to which attention will now be directed, were made known to the American scientific world by Professor H. James Clark, of Pennsylvania, U.S.A., who described and figured four species only, three of these inhabiting fresh-, and the remaining one salt-water. Most unfortunately for science this authority did not long survive his discovery of these new forms, and had, consequently, no opportunity of further extending and fully maturing his acquaintance with the same. Since the death of Professor Clark no other investigator, with the exception of the contributor of this article, appears to have knowingly encountered a single representative of the group in question, which may thus be said to have vanished from scientific cognizance.

The first acquaintance made by the writer with the new group of Flagellate Monads now to be introduced was in the autumn of the year 1871, when occupied in investigating the infusorial fauna of a small pond situated in the North London district, and fed by water from the New River Company. What at first sight during these researches presented the aspect of numerous closely aggregated colonies of a minute species of *Epistylis*, resembling the *E. botrytis* of Ehrenberg, proved upon more accurate examination and with the aid of a magnification of about 700 diameters, to be identical with the new type introduced by Professor Clark a few years previously, under the title of *Codosiga pulcherrima*. A representation of this earliest discovered and very elegant compound pedicellate monad will be found at Plate III. fig. 9, accompanying this article. The identity and structural peculiarity of this type having been once recognized, a very brief investigation sufficed to detect in the water of this same pond the whole of the three fresh-water species originally found

* See article on "Recent Researches in Minute Life," by H. J. Slack, F.G.S., Pop. Sc. Rev., vol. xiv. p. 245. 1875.

and described by Professor Clark, and in addition, a fourth and still more remarkable and luxuriant-growing variety. A brief announcement of this discovery within British waters of these interesting Flagellate types, with notes upon a few other allied forms, was communicated to the November meeting of the Royal Microscopical Society of London, and appeared in the Society's Journal for January 1872. From that period up to the present date continued researches by the writer in the same fertile field have been so far rewarded that the borders of this interesting, and as now shown widely distributed group, have had to be extended for the admission of some forty or fifty well-marked species. From a numerical point alone, indeed, it has now been demonstrated to occupy as important a position as any of the leading and natural divisions of the lower Protozoa recognized previous to this discovery: while in structural organization they are found to exhibit so novel an aspect as to demand the creation of a new sectional title equivalent to that of an order, if not a class, for their reception.

A glance at the two plates illustrating this article (perhaps already taken), will at once place the reader *en rapport* with the essential characteristics and more important known varieties of this newly discovered group, and which are here reproduced with considerable reduction in both size and number from the fuller details that accompany an extended monograph of the same now awaiting publication.* The most prominent feature of all these types, and one that serves to conspicuously distinguish them from all previously known Protozoic forms, is the presence at the anterior extremity of each individual monad of a hyaline, wineglass-shaped expansion, from the centre of the base of which the long lash-like flagellum takes its origin. On this remarkable wineglass-shaped structure Professor Clark originally bestowed the appropriate title of the 'collar,' and by this appellation it will hereafter be distinguished. Specifically, this delicate hyaline organ, the collar, is of such extreme tenuity that its true form and nature can be brought out only by a very careful adjustment of the achromatic condenser or other accessory illuminating apparatus employed, and is even then exhibited to the greatest advantage by supplying the type under examination with artificial food, such as carmine or indigo. Under the condition last premised it will be found that this collar consists of a thin infundibuliform film of sarcode that may be protruded from and withdrawn at will into the general substance of the monad's body in the same manner as the sarcode prolongations

* These fuller details are embodied in "A Monograph of the Collar-bearing Flagellata, &c., &c." communicated to the meeting of the Linnean Society held June 21, 1877.

or pseudopodia of an amœba or other Rhizopod. As in the pseudopodia of certain Rhizopods, such as the Foraminifera, it will likewise be found that notwithstanding the extreme tenuity of this sarcode film, a circulation of its substance is being constantly maintained, flowing upwards on the outside, over the distal edge or rim, and downwards on the inner surface, at the base of which it again comes in contact and merges with the general sarcode of the body. The services performed by this wineglass-like film of sarcode as a branchial or respiratory organ are doubtless considerable, but this by no means represents its most important function. In conjunction with the centrally enclosed vibratile flagellum it represents the most admirable trap or snare for the capture and retention of food that can be possibly imagined. Whirling round with inconceivable rapidity this last-named organ, the flagellum, creates a strong current in the water, setting from behind forwards in the direction of its own apex, and bringing with it all such tiny organic particles as do not possess sufficient power to stem its tide. But for the outspread collar these atomic particles would simply hurry with the stream past the monad's body and out of reach. Not for them, however, such an easy passing of the rapids. The dangers of dread Scylla lurk midway in the whirlpool of Charybdis! In the midst of their swift career they strike against the outer surface of the almost impalpable film of sarcode of which the collar is composed, and to this they now adhere as tenaciously as the snared bird to the lime-covered twig, or an incautious fly to a spider's web. Then slowly, almost imperceptibly, the captive atoms, be they alive or dead, are carried along with the circulating current of the collar's substance, until, on reaching the base of the interior of this structure as just now described, they are there engulphed within the sarcode substance of the monad's body as within a living grave. A diagrammatic illustration of the *modus operandi* of this remarkable feeding process, and also the aspect presented by one of these monads that was induced to make a hearty meal off minute particles of carmine, will be found at Pl. III. fig. 19. The food-particles after ingestion, as above, are gradually accumulated into spherical agglomerations and then passed within the interior of the body in a manner identical with that accompanying the feeding process of Vorticella or other of the higher Infusorial types. Refuse, or undigested residual particles of food, are finally liberated from the same area, limited by the base of the collar within which they primarily gained access. In common with apparently all other representatives of the Protozoa, these minute collar-bearing monads possess from one to two or more of those rhythmically expanding and contracting spaces distinguished by the title of "contractile vesicles." With these structures there is usually

associated the function of a rudimentary heart or respiratory organ, and in this particular group they are most generally situated at the posterior extremity of the monad's body.

Passing now from such characters as are shared in common by all the members of the Flagellate group to those which serve to distinguish them individually from each other, one is amazed at the infinity of form and variation in the arrangement of similar primary elements that are presented. The essentially plant-like aspect of many of these constitutes one of their most conspicuous features, to which has also to be added the remarkable extent to which will be here found foreshadowed on a much more minute but surpassingly luxuriant scale those individual or aggregated types of growth hitherto supposed to be confined to the more highly organized Ciliate order of the Infusoria. Examined from this latter point of view, the various species of *Codosiga*, consisting of numerous individual monads grouped together on a simple or branching footstalk, immediately recall to mind the compound pelicellate colonies of *Epistylis* or *Zoothamnium*; few, however, among these latter presenting such an exuberance and symmetry of growth as is instanced by the forms *Codosiga cymosa*, *alloides*, and *umbellata*, illustrated by figs. 1, 4, and 5, on the first of the accompanying plates (Pl. III.). The solitary species, belonging to the genus *Monosiga*, again, *ib.* figs. 16 and 18, may be accepted as corresponding with the simple and initial factor of the group typified in the same higher Ciliate order by the genus *Vorticella*. This simile in association with the family of the Vorticellidæ may be carried yet further, for while among these latter there occur genera, *e.g.*, *Cothurnia* and *Vaginicola*, in which the animalcules secrete around them chitinous protective sheaths or loricæ, so likewise we find what may be regarded as an homologous structure repeated in the genus *Salpingœca* (Plate IV. figs. 2, 9, 11, &c.), though in this instance with a diversity of contour altogether unapproached in either of those higher types. This genus *Salpingœca* is alone, in fact, worthy of independent study if only on account of the exquisite variety of form presented by these protective sheaths, many of which may be said to vie in chasteness and elegance of design with the classic vases and amphoræ of the ancient Greeks. In the genus *Lagenœca* (Plate IV. fig. 42) is found a freely floating loricate type, which may be compared with the Ciliate genera *Tintinnus* or *Codonella*; while in *Polynœca* (Plate IV. fig. 1) is encountered a variety whose compound lorica resembles the polypary of a minute Sertularian Zoophyte, and which has no parallel among that higher order of the Protozoa with which previous comparisons have been instituted.

Not less interesting than the varied forms of the protective loricæ of these collar-bearing monads as above referred to, are

the protean shapes assumed at will by their minute occupants during both their adult and developmental states. A variety of the more remarkable of these will be found represented in the accompanying illustrations. Thus one of the most cosmopolitan representatives of the tribe, *Salpingœca amphoridium*, while under ordinary conditions exhibiting that aspect characteristic of all other members of the group broadly described on a preceding page, is at times, to all but the initiated, metamorphosed beyond recognition. In one of these phases (Plate IV. fig. 4) it will be seen that while the flagellum remains extended, a portion of the body-sarcode of the monad is protruded from the aperture of the lorica. A still more singular form frequently assumed by this same species is delineated at fig. 5 of the same Plate. Here both the collar and flagellum have entirely disappeared, and one-half or more of the body-substance is projected from the orifice of the lorica in the form of numerous lobate processes resembling the pseudopodia of a *Difflugia*, to which Rhizopodal type the creature now bears a close resemblance. By patiently watching an example presenting this Difflugian aspect, it was found that in a little while the protruded lobate portion became gradually separated from the posterior half, and floated away in the form of a minute stellate amœba; this subsequently attaching itself, developed a new lorica, and grew into a collar-bearing form, identical with that from which it originally sprang. The posterior half, left in the parent domicile, speedily acquiring a new collar and flagellum, is not to be distinguished from the normal aspect it presented previous to entering upon the process of transverse fission. Another and characteristic phase frequently observed in association with this same species is that quiescent, or "encysted," condition represented at Plate IV. fig. 7. During this period of its life-history all external signs of vitality are suspended, and the body of the monad shrinks into a spherical or ovoid shape within its flask-like habitation. A little later this encysted monad breaks up into numerous locomotive spore-shaped bodies, each furnished with a single flagelliform appendage. These, after dispersing themselves through the surrounding water, become attached, and growing to the likeness of the parent form lay severally the foundation of future colonies. An illustration of the liberation and dispersal of the locomotive spores or germs of an allied species, *S. fusiformis*, is given at Plate IV. fig. 26.

While the mode of increase by fissi-gemmation in the loricate type *Salpingœca* almost invariably takes, as already described, a transverse direction, it appears in the compound pedicellate genus *Codosiga* to as constantly follow a longitudinal one, it being, indeed, this latter mode of fission, accompanied by the adherence to one another of the individual monads by their bases,

or to the common supporting stem, that the luxuriant colony-forms of this beautiful genus are produced. A single monad of *Codonæca pulchernima* is shown at Plate III. fig. 10 in the act of dividing into two by this last-named characteristic mode of fission, and in which process it will be seen that the division extends to both the hyaline collar and the flagellum. These several processes of multiplication—by fission in a twofold manner and by the breaking up of the parent body, after encystment, into locomotive spores—are found to persist not only throughout this special collar-bearing group, but must now evidently be accepted as presenting the normal method of reproduction among all *Protozoic* structures. Preceding this more important mode of increase by the resolution of the parent body into spores, it frequently happens that two or more individuals coalesce or fuse intimately, mostly in an amœboid form, with one another, and produce one single capsular encystment. This process, however, does not appear in all cases to be essential. Taken as a whole, the representatives of the protozoic or unicellular animal sub-kingdom are thus shown to agree in their reproductive and developmental phenomena with the unicellular and other lower cryptogamic plants, and might therefore with equal justice be appropriately denominated cryptogamic animals. These two animal and vegetable groups again exhibit a further striking parallelism, inasmuch as neither in the former does a true egg, nor in the latter a true seed, constitute the essential reproductive product, as is the case with all of the more highly organized structures on either side. Among the developmental phenomena, supplementary to the foregoing, presented by the collar-bearing group here specially considered, that associated with the building up of the protective sheath of the loricated genus *Salpingœca* is well worthy of notice. This structure, as shown in the case of *S. ampulla* at Plate IV. figs. 13 and 14, takes its origin as a mere mucus-like excretion from the surface of the monad's body, and at a period prior even to the appearance of the collar. In a very short time after its excretion, the lorica acquires its normal consistency, and is then of considerable solidity, as is proved by its retention of its form for a considerable interval after the death of its original occupant.

Absorbing as the investigation of these minute independent collar-bearing monads is sure to become to any microscopist adopting the same as a subject for study, on the merit of their intrinsic beauty and variety of form alone, it has yet to be shown that they possess a still more interesting and important bearing with reference to their relationship or affinity with certain other animal organisms. Prof. H. James Clark, the authority already quoted as the first to report the occurrence [illegible] American waters of some three or four varieties of these

collar-bearing species, simultaneously announced his discovery that one of the calcareous-spiculed sponges (*Leucosolenia botryoides*, Bwbk.) consisted of aggregations of essentially similar collar-bearing monads, immersed within the structureless sarcode or spicule-producing element. This important discovery, confirmed by an examination of other species, Prof. Clark regarded as completely setting at rest the long-vexed question concerning the true nature and affinity of the sponges, and conclusively demonstrating the necessity of their recognition as colony-building flagellate infusorial forms. Professor Clark's decease shortly after this announcement, together with the novel theory concerning these same organisms that was brought forward at about the same date by Professor Ernst Hæckel, and in which it was sought to show that the sponges were referable to a far more highly organized animal group, served to almost entirely divert the attention of biologists from those views that originated with the first-named authority. Notwithstanding, however, this temporary diversion of scientific thought into a novel, and, at first sight, sufficiently plausible channel, the researches of recent investigators are tending to confirm the views of the American naturalist, almost all of these being unanimous in recognizing that the ciliated lining of the various-shaped sponge-cavities is essentially composed of collar-bearing flagellate cells similar to those just described as existing in *Leucosolenia botryoides*. Although thus admitted, however, by such authorities to constitute an important element in all sponge-structures, very few are at present inclined to concede to these collar-bearing flagellate cells the primary position assigned to them by Professor Clark. In accordance with the view of the former, indeed, each such flagellate collar-bearing cell is not to be regarded as a separate and independent monad or individual, but merely as a single cell-constituent of a continuous and epithelium-like internal lining membrane.

The above-mentioned opposing views held respecting the true nature and affinity of the sponges may thus at the present day be said to provide material for as fierce a controversy between leading scientific authorities as was maintained in similar circles during the first half of this century relative to the claims of these same organisms for admission into the ranks of the animal kingdom, and which has not for so very long a while been universally accorded them. If, as Prof. Hæckel and the advocates in whole or in part of his theory assert, sponges are composed of separate multicellular membranes or tissues, they undoubtedly find their nearest allies among the Cœlenterata, including the sea-anemones and hydroid zoophytes. If, on the other hand, as represented by Prof. Clark, they consist of aggregations of unicellular *collar-bearing* flagellate monads, their

place is unquestionably adjacent to the more simple unicellular Protozoa, including the ordinary monads, Rhizopoda, and Infusoria. The fuller light so much needed to determine once and for all this abstruse but exceedingly interesting question of the true nature and affinity of the sponges, has without doubt been considerably obscured through the absence, since the death of Prof. Clark, of all further testimony or corroborative evidence relative to those independent collar-bearing monad forms upon which his arguments were essentially based, and which, if his views were correct, might be expected on a closer and more extended acquaintanceship to yield parallel structural and developmental data of the greatest importance. This hiatus in the chain of evidence was early recognized by the writer, and may be said to have directly led to the investigations pursued in reference to this group within the past five or six years, resulting in the discovery of the innumerable previously unknown species, many of which are figured for the first time in these pages. Having this amount of material available for correlation and comparison, the case for the advocates of the protozoic nature of all sponges has been immeasurably strengthened, while little if any substantial foothold would seem to be now left for the adherents of the opposite or cœlenterate persuasion. Examining numbers of sponges and comparing the structure and manifestations of their collar-bearing unicellular constituents with those of the solitary or colony-forming individuals of the genera *Codosiga*, *Salpingœca*, and others previously referred to, the phenomena elicited were found to be altogether identical. Every separate collar-bearing cell in these sponge-structures was found in a similar manner to possess a separate and independent existence, capturing its food in the same manner with its exquisitely hyaline wineglass-shaped trap of circulating sarcode, possessing the same posteriorly situated and rhythmically opening and closing contractile vesicles, dividing by longitudinal or transverse fission, and ultimately encysting and breaking up into countless germs or spores destined to grow to individuals identical with the parent form, and further extend the borders of the commonwealth. In common with the independent collar-bearing types, these sponge-monads were found also to be possessed of an equal or even greater amount of plasticity of external form, retracting their characteristic collar and flagellum, and assuming an amœboid aspect in a manner closely identical with what has been already described of *Salpingœca amphoridium* and *fusiformis*. Often, again, these sponge monads (see Plate III. fig. 31), having the collar and flagellum withdrawn, throw out long, slender, capitate processes, which communicate to them an appearance closely resembling that of certain of the *suctorial* animalcules or *Acinetœ*.

That sponges, taken as a whole, possess a something over and above what is encountered in the simple, independent, collar-bearing monad types cannot for a moment be denied. What the distinction is, and the extent to which it complicates or masks their true nature and affinities, may be briefly explained. A sponge-body, cut through and examined with the microscope, though presenting at first sight an exceedingly complex type of structure, will be found on closer inspection to consist of a few very simple elements. Occupying, in the majority of species, the largest, but by no means most essential portion of its composition, is the glairy, gelatinous sarcode, or syncytium, which forms, as it were, the basis or superstructure in and upon which all the other elements are distributed. Within its substance are imbedded, or, in fact, originated, when present, the various skeletal components, whether spicules, horny fibre, or a combination of the two, that give to the complete sponge that amount of rigidity or variety of contour that distinguishes the various species. Abundantly scattered throughout the substance of this slimy matrix will likewise be found the amœbiform bodies of every shape and size to which the name of "cytoblasts" has been latterly applied. Last and most essential of all are the collar-bearing flagellate monads or spongozoa, identical in form and structure with the independent collar-bearing species already introduced. These constituent sponge-monads most usually either line the entire surface of the inner cavities of the sponge, or occupy special spherical chambers within the same. These three living elements or factors now enumerated, namely, the glairy and structureless syncytium, the amœbiform cytoblasts, and the collar-bearing, flagellate monads, once intelligently recognized, the reduction of the sponge-structure to a still more simple formula is, with the light now afforded by a knowledge of the structure and developmental history of the independent collar-bearing types, a comparatively easy task. With such accessory light it may be shown, indeed, that the collar-bearing monads are the *only* essential factors, and that towards them all the remaining structures occupy an entirely subordinate position. Given, in fact, a single one of these constituent monads, and a perfect sponge-body can in a little while be progressively built up. By a mucus-like exudation from its surface the basis of the syncytium is laid in a manner absolutely identical with the process by which the at first mucilaginous, but afterwards indurated lorica, or protective sheath of the genus *Salpingœca* is originated.* By a re-

* Several higher ciliate infusorial forms produce a mucilaginous investing sheath by a similar process of exudation. In one of the most conspicuous of these, *Ophrydium versatile*, large colony-masses are formed containing

peated process of cleavage or fissiparous multiplication the original sponge-monad mostly multiplies itself, though still more rapidly and effectually by the subsequent encystment and breaking-up of the mulberry-like cells into spores. In the independent collar-bearing types as already shown, the germs or spores resulting from this process of encystment are discharged into the surrounding water, and thus dispersed to considerable distances. In the sponges, however, this act of encystment takes place within the substance of the sponge, and within its substance are the spores released. In this element, moreover, they immediately find a most appropriate pabulum or matrix for their future development, and are to be encountered in examination in every phase of transition. As it has been previously shown that the larval or initial conditions of the independent collar-bearing monads take the form of either amœbæ or simple flagellate monads, so also it will be found that the collar-bearing sponge-monads commence existence as similar simple units. Aided, indeed, by the light afforded by the developmental phenomena of this independent group it is easy to recognise that the amœbiform bodies of every variable shape and size dispersed among the syncytial element of the sponges are merely the larval or transitional conditions of the adult collar-bearing monads which they ultimately resemble. Between the amœbiform and the adult state there is usually also an intermediate stage, in which the sponge-monad, not having yet acquired the characteristic collar, possesses a single lash-like flagellum. An illustration of such intermediate flagellate types, taken from an example of a siliceous-spiculed sponge, *Halichondria panicea*, will be found represented at Plate III. fig. 32.

In addition to developing by fission, or as simple units or individuals, from the amœboid to the collar-bearing stage, and thus contributing to the further extension of the parent colony it remains to be mentioned that in many, if not all, sponges there is another process of development attended with more complex phenomena, contributing to the production of detached and free-swimming monad-aggregations specially adapted to secure the wider distribution of the species. In this instance the amœbiform units, either as mature cytoblasts or as collar-bearing monads returned to an amœboid state, fuse or coalesce intimately with one another in variable numbers, producing by such an amalgamation an amœbiform body of considerable size. By a process of geometrical cleavage or multiple fission

hundreds of separate individuals all enclosed within a common gelatinous investing sheath, and presenting a general aspect clearly resembling that of the fresh-water sponge, *Spongilla fluviatilis*, with which it is frequently associated.

his enlarged amœboid body now gives origin to a structure so losely resembling the "morula" that results from the primary egmentation of the ovum of all higher animals, that the nature f a true egg or ovum has been inaccurately attached to it by ome authorities. By degrees each constituent segment of this noruloid body assumes a lengthened conical form, and, acquiring a terminal flagellum, presents in the aggregate the aspect given at Plate III. fig. 27.

Developing still further, this moruloid body finally, and in its most characteristic phase, exhibits the form shown at fig. 28 of the same plate, and in which condition it may be described as a spherical or ovoid aggregation, hollow within, of typical collar-bearing monads or spongozoa, individually identical with those of *Codosiga pulcherrima* or any of the independent collar-bearing types figured on the same plate. Floating away in this condition the collars and flagella of the sponge-monads are subsequently retracted, a syncytial exudation is thrown out as a veil around them, the spicules or other skeletal elements make their appearance in the same, and the body, attaching itself by some point of its periphery, usually the posterior one, speedily presents in miniature all the essential features of the parent sponge which gave it birth. The special collar-bearing cells now project into the interior cavity, opening externally by a single flue or osculum, and rapidly multiply by those various processes of fission or resolution into spores already described.

By those hitherto insisting on the recognition of sponges as animals qualified to rank with the Cœlenterata or lowest Metazoa rather than with simple unicellar Protozoa, the free-swimming compound gemmules just discussed have been seized upon as yielding the most conclusive evidence. The various arguments, however, brought forward in association with these structures in support of this cœlenterate view, have been considerably weakened since the first attempt made by Prof. Hæckel to establish for them a form and structure identical with his typical but hypothetical "Gastræa," or larval stockform of all animals higher than the Protozoa. This "Gastræa," consisting of a capsular body with a single terminal orifice and body-wall composed of two separate cellular membranes, an ectoderm and endoderm, was supposed to find its ideal personification in the compound ciliated sponge-gemmule. A more intimate and accurate acquaintance with these bodies has, however, revealed to numerous observers the entire untenability of this hypothesis. It is now definitely determined that there is no separation of the walls of the gemmule into an outer and inner cellular membrane or ectoderm, as originally premised, and no terminal orifice leading into the central cavity. The strongest, and apparently the only argument, indeed, that can now be brought forward in favour of the

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[illegible] *Protozoa* to the attention of wo[rkers] [illegible] it is much to be desired that they shall su[bmit] [illegible] such observations as they may make in connection [with] [illegible] by a practical examination of the structure of all [the] [illegible] forms in the living state to which they may have a[ccess] [illegible] other field our knowledge may be said as yet to exte[nd] [illegible] further than the threshold, and in each of the same there is

* An illustration of this interesting type will be found in vol [illegible] Plate [illegible] XIV, figs. 9 and 11, accompanying the article quoted i[n] [illegible] footnote of page 110.

bably more original discovery waiting to be achieved than in any other group of the organic world. The forty or more specific types of the independent collar-bearing forms that have rewarded the writer's desultory investigations spread over some five or six brief years, may be safely accepted as representing but a very small instalment of the innumerable varieties that are doubtless awaiting a more thorough and systematic research; while of the sponges it may be said that we are as yet but imperfectly acquainted with the complete structural and developmental phenomena of even half a dozen out of the many hundred discovered species. In reference to these last-named organisms it is worthy of remark, before taking leave of them, that Professor H. James Clark, when first pointing out the intimate relationship between their essential living units and the two or three independent collar-bearing forms discovered by himself, hazarded the opinion that future investigation would probably reveal that different groups of sponges were composed of monads, corresponding in individual structure or presenting combinations of the various independent generic types; and this anticipation has been remarkably fulfilled in the case of one of the simplest known sponge forms recently discovered, and to which the name of *Gastrophysema primordialis* has been given by Professor Hæckel. A small fragment of this interesting variety with its characteristic internal lining of collar-bearing monads is shown at Plate III. fig. 38, and this type may be said to present an amalgamation of the generic characters of the two genera *Codosiga* and *Salpingœca*, certain of the monads being naked as in the former genus, and others enclosed within a flask-shaped lorica, as in the latter one. In the last-named instance the monad illustrated has entered into a quiescent or encysted condition within its lorica, presenting under such circumstances an aspect absolutely identical with the similar encysted condition of *Salpingœca amphoridium* shown at Plate IV. fig. 7. Professor Hæckel, unaided by an acquaintance with the independent collar-bearing forms here described and illustrated, and assuming for all sponges a cœlenterate type of organisation, has singularly associated with these flask-shaped loricæ and their encysted contents the structure and functions of rudimentary glandular organs.

Before leaving the microscopist to make his first essay in that new and fertile field for investigation to which his attention is now directed, a few hints as to the conditions under which the most complete success is likely to be achieved may prove acceptable. The first matter of importance is his apparatus; and here, should he not be in a position to command one of the highly perfected achromatic object glasses of our best English makers, let him be by no means discomfited. A German one-sixteenth

[illegible] immersion lens, yielding a magnifying power of from 7 to 2,000 diameters and upwards, may be obtained at Mr. Cha Baker's, of 244 High Holborn, for the modest sum of 3*l*. S an object-glass will be found equal to interpreting the form a structure of any of the numerous types figured in the acco panying plates, and with such a lens, indeed, the whole of th forms were, with but few exceptions, in the first place discove and delineated by the writer.

The mechanical appliances being decided on and obtained, remains only to select the material for investigation. Eit salt or fresh water will be found to yield its quota of the ty required, and those frequenting the last-named element, bei usually the more accessible, will most probably command fi notice. Here the investigator will find his time most profita employed in procuring from the nearest weedy pond or ditch bottleful of the finely divided leaves of Myriophyllum, or tangled confervoid growths, in either case selecting more es cially those brown-head specimens coloured by a dense incr tation of other more minute vegetable and animal parasi growths. Care should likewise be taken to enclose with t water as large a number as possible of the specimens of *Cycl* and other Entomostraca abundant in such situations, and which will be frequently found attached species rarely, if ev to be met with elsewhere. Patiently exploring every filam tous division of the above-mentioned weeds with the lower the two powers employed, it will be scarcely possible to m encountering one or more of the species illustrated in the accompanying plates. As first seen with this lower or reconnoitri power, it will of course be almost impossible to distingu the characteristic collar, and the monads will appear as m luminous specks adherent to the plants under examinati Meeting with these, the higher power must be brought i focus, when the true nature of the organisms will be reveal Among the varieties which are likely at first to be encounte are, perhaps, the two loricated species *Salpingœca amphoridi* and *fusiformis* (See Plate IV. figs. 3 and 23), the former oft completely incrusting several consecutive joints of vari thread-like confervæ, while the latter will occur as solitary in viduals scattered about at uncertain intervals. On the stron fulcrum for support afforded by the leaf-partitions of Myr phyllum, the illoricate species *Codosiga pulcherrima* (Pl III. fig. 9) is often present in great profusion, its sociable dicellate colonies being so thickly placed as to present the appe ance of a perfect little forest of crystal-fruited trees. M rarely, under similar conditions, the extremely elegant a symmetrically tripartite branching pedicellate form *Codosi umbellata* (Plate III. fig. 4) may be likewise met with.

At the outset, considerable difficulty will doubtless be experienced in the satisfactory definition of the hyaline collar characteristic of all the members of this group, a most careful manipulation of the light being often requisite to show this structure to advantage. It frequently happens again that when the entire contour of the wineglass-shaped collar is not to be distinguished, its presence is indicated by the clearer outline of its two lateral margins, which, standing out at an acute angle from the perpendicular line formed by the central flagellum, present the aspect of two additional hair-like processes. The appearance of this organ, when seen as described in the last sentence, is indicated at Plate IV. fig. 41, illustrative of the so-called "animalcule with ear-like processes," figured many years since by Mr. Carter, but which undoubtedly represents a species of *Salpingœca* with the characteristic collar indistinctly seen. In a similar manner other species now shown to belong to this newly discovered collar-bearing group have from time to time been imperfectly figured by various authorities, who, when encountering them, have not employed sufficient magnifying power or that mode of illumination requisite for the interpretation of their true character.

Having, with the assistance of these few hints, made himself familiar with but two or three only of the interesting types here introduced to his notice, the investigator will experience but little difficulty in extending the circle of his acquaintanceship with the same, and can scarcely fail before long to become so absorbed in admiration of the infinite variety of form and vital phenomena they present, as to regard as lost any further time bestowed on the markings of either Diatoms or Podura scales—*d hoc genus omne.*

EXPLANATION OF PLATES.

With one or two exceptions all the figures in the accompanying plates represent the objects delineated as seen with a magnifying power of from 500 to 2,000 diameters.

PLATE III.

Fig. 1, 2. Adult colonies of *Codosiga cymosa*, Sav. Kent.
„ 3. A single monad of the same species in an encysted state.
„ 4. Adult colony of *Codosiga umbellata*, S. K.
„ 5. Adult colony of *Codosiga alloides*, S. K.
„ 6. A single monad of the same with the body and collar retracted.
„ 7. Monad of the same species in its fully expanded state.
„ 8. Adult individual of the solitary form *Monosiga angustata*, S. K.
„ 9. Adult colony of *Codosiga pulcherrima*, J. Clk.

FIG. 10. A monad of the above dividing by longitudinal fission.

„ 11. A monad of the same species, with the collar and flagellum withdrawn, emitting pseudopodic processes.

„ 12. An encysted monad of the same species with the body broken up into spores.

„ 13. An adult colony of *Codosiga grossulariata*, S. K.

„ 14. An adult colony of *Codosiga pyriformis*, S. K.

„ 15. Single individual of *Monosiga brevipes*, S. K.

„ 16. *Monosiga globularis*, S. K., showing at *a* and *b* free-swimming and attached larval forms.

„ 17. Adult colony of *Codosiga candelabrum*, S. K.

„ 18. Single individual of *Monosiga gracilis*, S. K.

„ 19. Body of the same still further enlarged and diagrammatically illustrating the feeding process described at p. 117. The arrows indicate the direction of the current caused by the rotatory motion of the flagellum and the course taken by the food particles on striking against and adhering to the collar. *fl.* Flagellum. *c.* Collar. *n.* Nucleus. *f.* Food-particles. *cv.* Contractile vesicle.

„ 20. Free-floating colony of *Astrosiga disjuncta*, S. K.

„ 21. Four monads of *Monosiga consociatum*, S. K.: at *a* an individual in a quiescent or encysted state.

„ 22. An individual of the same species assuming an amœboid form and exhibiting extensive internal vacuolation.

„ 23. Adult free-floating colony of eight monads of *Desmarella moniliformis*, S. K.

„ 24. Colony of two individuals of *Codosiga furcata*, S. K.

„ 25. Animalcule figured by Stein as probably the young of *Opercularia nutans*, but probably identical with the above species.

„ 26. Abnormal colony-form of *Codosiga cymosa*, S. K.

„ 27. Free-swimming multiple-fission gemmule of a calcareous sponge, *Sycon ciliatum*, in diagrammatic longitudinal section.

„ 28. A more advanced stage of the above, in which the separate flagellate cells have acquired the characteristic collars of the adult sponge-monads.

„ 29. An adult sponge-monad of *Grantia compressa* in its normally expanded state. *n.* Nucleus. *cv.* Contractile vesicle.

„ 30. A collar-bearing monad from the same sponge emitting pseudopodic processes from its posterior extremity.

„ 31. A monad from the same sponge with the collar and flagellum withdrawn assuming an *Acineta*-phase.

„ 32. Initial or mono-flagellate larval condition of a siliceous sponge, *Halichondria*.

„ 33. Sporocysts of a siliceous sponge, *Halichondria*.

„ 34. Portion of syncytium of a calcareous sponge, *Leucosolenia botryoides*, having imbedded in its substance a sporocyst containing spores, and also free spores recently liberated from a similar cyst.

„ 35. Section through a monad-chamber or 'ampullaceous sac' with its contained collar-bearing monads, and portion of the syncytium of a siliceous sponge. *a.* Ampullaceous sac. *b.* Amœboid particles or cytoblasts.

Fig. 36. Sporocyst of a species of *Halichondria* bursting and liberating its contained spores.

„ 37. Sporocyst and liberated spores of another siliceous sponge.

„ 38. Fragment of the cavity-lining of *Gastrophysema dithalamium* (Hæckel), one of the simplest known sponge forms; showing two collar-bearing monads, two larval or amœboid cytoblasts, and a flask-shaped sporocyst, copied from Prof. Hæckel's illustrations of the species.

PLATE IV.

Fig. 1. Adult colony-form of *Polynœca dichotoma*, S. K.

„ 2. Colony of numerous individuals of *Salpingœca amphoridium*, J. Clk., attached to a confervoid filament.

„ 3. A single individual of the same species in its normal and fully expanded state.

„ 4. Monad with collar withdrawn but flagellum remaining, and protruding a portion of its body-sarcode from the orifice of its lorica.

„ 5. Monad with collar and flagellum withdrawn, and the body-sarcode protruded as lobate pseudopodic processes.

„ 6. The protruded portion of the above detached in the form of a minute stellate amœba.

„ 7. The quiescent or encysted condition of the same species.

„ 8. *Salpingœca inquillata*, S. K., larval form in the act of constructing its lorica.

„ 9. Adult individual of the same species.

„ 10. An individual of the same species multiplying by transverse fission.

„ 11. *Salpingœca ampulla*, S. K.

„ 12. Deserted lorica of the same species exhibiting fluted markings.

„ 13. An early phase of the same species in which the lorica is as yet only in a mucilaginous condition; the uniflagellate monad, marked *a*, adherent to the top left-hand corner of this sheath, is a larval form of the same species.

„ 14. The same larval form represented at 13*a*, commencing the construction of its lorica by a process of exudation.

„ 15. *Salpingœca cylindrica*, S. K.

„ 16. Sociable colony of *Salpingœca tuba*, S. K.

„ 17. Two monads of *Salpingœca gracilis*, J. Clk.

„ 18. *Salpingœca cornuta*, S. K., the monad adherent to its lorica posteriorly by three pseudopodic prolongations.

„ 19. Another monad of the same species adherent to its lorica by a single and elastic pedicelliform extension of its body substance.

„ 20. An individual of *Salpingœca gracilis*, J. Clk., dividing into two by transverse fission; at *a* the separated anterior half swimming off as a simple uniflagellate monad.

„ 21. Two individuals of *Salpingœca longipes*, S. K.

„ 22. Empty lorica of *Salpingœca teres*, S. K.

„ 23. *Salpingœca fusiformis*, S. K., in its normal and fully expanded state.

„ 24–26. Three developmental conditions of the same species illustrating respectively the amœboid, encysted, and sporuliferous phases.

FIG. 27, 28. *Salpingœca minuta*, S. K., in its normal and amœboid phases.
„ 29. Early or larval condition of the same species.
„ 30. Empty lorica of *Salpingœca curvipes*, S. K.
„ 31. *Salpingœca ringens*, S. K.
„ 32. *Salpingœca urceolata*, S. K.
„ 33. *Salpingœca pyxidium*, S. K.
„ 34. *Salpingœca amphora*, S. K.
„ 35, 36. *Salpingœca marina*, J. Clk.
„ 37. *Salpingœca tintinnabulum*, S. K.
„ 38. Encysted condition of the same species.
„ 39. *Salpingœca napiformis*, S. K.
„ 40. *Salpingœca petiolata*, S. K.
„ 41. *Salpingœca Carteri*, S. K.
„ 42. *Lagenella cuspidata*, S. K.
„ 43. *Salpingœca Wallichi*, S. K.
„ 44. Two individuals of *Bicosœca socialis*, S. K.
„ 45. *Bicosœca lacustris*, J. Clk. in its normally extended state.
„ 46. The same withdrawn within its lorica.
„ 47. The same species dividing by transverse fission.
„ 48. Free-swimming product of the above process of transverse fission.
„ 49. Spore-condition of *Bicosœca lacustris*.
„ 50. *Codonœca costata*, J. Clk.
„ 51 *Dinobryon epistyloides*, S. K.
„ 52. *Bicosœca bulla*, S. K.
„ 53. *Bicosœca gracilipes*, J. Clk.
„ 54. *Dinobryon sertularia*, (Ehr.), a compound colony of eleven individuals showing at *a* the method of gemmation.
„ 55. A single individual of the above further enlarged. *n*. Nucleus. *e*. Eyespeck. *cv*. Contractile vesicle.
„ 56. A compound colony of *Dinobryon petiolatum*, Duj.

Flagellate Protozoa

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ASTOR, LENOX AND
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HE CHINA CLAY INDUSTRY OF CORNWALL AND DEVON.

r J. H. COLLINS, F.G.S., Secretary of the Royal Institution of Cornwall.

TRAVELLERS by the Great Western Railway in the West of England, after crossing the great Albert Bridge at Saltash, passing over the tree tops in the deep valleys about Liskeard, and leaving the deserted copper mines of St. Blazey and Par on their right hand, usually observe truckloads of peculiar white substances occupying the sidings, and are especially struck with the whiteness of the streams crossed by the railway—which closely resemble rivers of milk.*

Naturally they begin to ask what it means, and the writer has often been amused by the gravity with which some fellow-traveller, who seems to think it disgraceful to confess ignorance on any subject whatever, vaguely talks of lime, or more boldly of chalk. Perhaps some native happens to be present, who politely assures him that he is in error—that neither chalk nor lime are present in any form—and that the peculiar whiteness is caused by a refuse product from the china-clay works in the vicinity. This of course settles the question usually; but if the original querist happens to be inquisitive or persistent, he soon finds that the native in most cases is entirely ignorant of the methods of working, the extent of the works, and the uses of the product, and if this is true of the intelligent native, still more is it true of the general public. Out of Cornwall it is a rare chance to find either commercial men, or even scientific geologists, who have any knowledge whatever of the peculiar industry which characterizes many parts of Cornwall and Devon, and especially the centre of Cornwall. Yet this industry is interesting in itself, employs a large number of men, and supplies every year more than 200,000 tons of the

* Notwithstanding the apparent opacity of the water from suspended particles of clay and mica, I have seen trout 8 or 9 inches long taken from these streams.

dazzling white clay, which never fails to attract the attention of tourists.

The object of the present paper is to describe the salient features of this industry. Most people know that "china" was first brought by the Portuguese from China—hence the name. It was called by them "porzellano," because it was supposed to be fabricated from sea shells: hence the term "porcelain;" but no real knowledge was obtained of the materials used until the publication of the reports of the Jesuit Father D'Entrecolles, in 1712, and of Count Réaumur, in 1729. These reports led to the establishment of the manufactories at Dresden, Sevres, and Plymouth—the last-named having been established in 1733. Up to 1745, the fine porcelain materials used in the Plymouth works were imported; but soon after that time, Mr. Cookworthy, the founder of the works, discovered "kaolin" (which he calls *growan clay*, now called *china clay*), and the "petuntze" (called by him *growan* or *moorstone*, and now known as *china stone*) similar to or identical with that used by the Chinese, in several parts of Cornwall in great abundance. In conjunction with Lord Camelford, he took out a patent for the use of these materials in 1768. How these materials are used in the manufacture of porcelain, earthenware, and more recently in many other British manufactures, forms no part of the subject of the present paper—this is limited to a description of the modes of occurrence and of preparation of the china clay and china stone.

China clay is prepared by washing a peculiarly white decomposed granite, which occurs very largely in the granite district north of St. Austell, as well as in many other parts of Cornwall—and also in Devon. This natural china clay rock, which has been elsewhere called "Carclazyte," is simply a granite composed of white or pale smoky quartz, white mica (lepidolite) sometimes a little greenish-yellow gilbertite, and white felspar, *in which the latter is partly or completely metamorphosed into kaolin*. This modification of granite occurs in areas of irregular form, generally much elongated in one direction, and extending to an unknown depth. It is in the West of England universally associated with quartzose and schorlaceous veins—evidently of later origin than the rock itself—which sometimes also contain oxide of tin. The greatest extension of the decomposed granite coincides with the "run" or "bearing" of the veins, and is more complete as the vein is followed downwards in depth.*

* In a paper read before the Royal Geological Society of Cornwall in 1876 I have given my reasons for believing that the decomposition has been produced *in situ* by fluids circulating within the fissures, joints, and shrinkag

Many of the so-called "deposits" of clay extend for a dis-
ıce of a quarter of a mile, half-a-mile, or even more, in the
ection of the veins, while their breadth may be only a few
hes, and seldom exceeds a few fathoms. It is true that
y wide masses of china clay are wrought in many places,
t these are invariably associated with a group of parallel
ins.

The granite rock is usually covered by a layer, from 4 to 30
t thick, of brown or yellow sandy earth, often full of angular
ces of hard granite, schorl rock, tourmaline schist, with
metimes a little tin ore, &c. This layer is called by the
rkmen "overburden," and it must be removed before the
y can be got at.* The process of working is usually as fol-
ws:—Let us suppose that a patch or band of suitable decom-
sed granite, called by the workmen a "bed of clay," has been
scovered in a hill-side. The first thing to be done is to drive
"adit-level" horizontally right into the hill beneath the bed
clay, the position and extent of which has been more or
s accurately determined by systematic "pitting" through the
erburden. This adit-level is a sort of tunnel—from 6 to 9
t high, and from 3 to 6 feet wide. While this level is being
iven, a large piece of the overburden is removed so as to expose
considerable area of the bed of clay.† A vertical opening or
aft is then made from the inner end of the adit, to the surface
the uncovered clay bed—partly by digging downwards from
ove ("sinking"), partly by digging upwards from below,
putting up a rise"). A square wooden pipe, having holes at
gular distances of a few feet in one of its sides, is then placed
the vertical opening, so as to keep open a communication
th the level below;‡ the remainder of the shaft is then either
led in or kept open for the removal of the coarse sand or
nes produced in working; and the regular washing of clay
ay be proceeded with. Of course the arrangements for obtain-
g the clay vary very much in different works. These different

cks of the granite—now occupied by the solid matter of the veins re-
red to above—and not as commonly stated in geological works by carbonic
d acting from above.

* This covering closely resembles some glacial deposits; but neither organic
nains, nor scratched stones, nor stones of foreign origin have been found
it, to my knowledge, although many acres have been removed in the various
y works.

† The term "clay" is applied indiscriminately in Cornwall to the decom-
sed granite rock, and to the true clay washed out of it.

‡ The holes are—except the top one—temporarily covered with pieces of
rd nailed over them. The whole contrivance is called a "button-hole
nder."

arrangements were described by the author in the "Journal of the Society of Arts," 1872.

"Granite, as is generally known, consists mainly of three distinct minerals, quartz, felspar, and mica. In the decomposed granite it is the felspar only which is decomposed, or converted into kaolin; but this renders the whole mass so soft that a pick or shovel may be readily driven into it to a considerable depth. The mode of working it is to break up a portion with a pick to a depth of several feet in a kind of slope around the mouth of the pipe or launder which passes down into the adit below. This is called a "stope." A stream of water is then made to flow over the broken lumps, which are kept well stirred up by a workman, called a "washer," whose duty it is to keep breaking and stirring them up. The water, clear at first, speedily becomes white and milky by washing out the soft decomposed felspar, and runs down to the bottom of the stope, carrying with it the quartz grains and flakes of mica. The quartz and the coarser mica flakes, called "sand" by the workmen, settle in a shallow pit, called the sandpit, from whence they are constantly shovelled out by a man placed there for that purpose—while the stream of clay water, carrying with it many minute flakes of white mica, passes on down the vertical launder and through the adit-level to be further treated.

The stream of clay water, if thick, contains usually about per cent. of clay, and perhaps one-half per cent. of mica in suspension. This is made to flow slowly through a succession narrow channels, called "drags" and "micas," in which the fi mica and a little clay are gradually deposited, while the bulk the clay passes on with the water, and falls into a circular p from twenty to thirty feet in diameter, and eight or ten fe deep, lined usually with granite blocks. Here it gradual settles to the bottom, while the clear water passes off at little depression in the rim of the pit, and may either pumped up to be used over again, or allowed to flow into t nearest river. This effluent water is often clear enough drink.*

Once or twice a day it becomes necessary to clean out t long channels, called "drags" and "micas," in which case t fine mica and clay, which has settled at the bottom, is wash out into the nearest watercourse by a stream of water, and t it is which foils the streams.

In some works, as at the celebrated Carclaze Mine, work

* Occasionally these pits are left filled with clay water, and undisturl for several weeks, when the intense blueness of the water equals that of so Alpine lakes, and is due to the same cause—the suspension of minute pa cles of solid matter.

as an open quarry for tin for four centuries, not only is the mica washed away in this manner, but the large quantity of sand produced is also washed away at night, and thus very large accumulations of sand have collected in the valleys below St. Austell, St. Blazey, and elsewhere.

The clay having settled in the pits to a consistency somewhat thicker than cream, is in old-fashioned works run out into shallow excavations called "pans." These are about two feet deep—the clay is put into them during the winter months, and is allowed to remain until nearly dry, when it is cut out in square blocks and piled up under sheds, or in the open air, till completely dry. By this mode of working a good deal of loss is experienced, as every block of clay is more or less injured at the surface by exposure for months to the vicissitudes of the weather, the invasions of sheep, cattle, and geese—which latter abound on the moors—and the mischief of stone-throwing boys. When thoroughly dry, therefore, every block has to be separately scraped before it is in a fit state to be sold.

The scraping operation is a peculiar and somewhat ghastly sight to those who see it for the first time. Gangs of tall women, white-aproned—every vestige of complexion hidden with white clay—stand at tables scraping the blocks all day long, with a little three-cornered scraper like a miniature Dutch hoe, and often dismally singing hymns which sound like dirges.

The advantage of air-drying is that no expense is incurred for fuel—the disadvantage is the loss incurred by scraping, the expense of scraping, and the large area required for the drying pans.

In more modern works the air-drying is mostly replaced by kiln-drying. Long kilns are built of fire-clay tiles covering brickwork flues from 60 to 100 or even 150 feet long. The clay from the circular pits is first run into large tanks, where it remains for a month or two, till pretty stiff. It is then taken into the kiln or "dry" on tramwaggons, and dried by throwing it upon the hot tiles. When dry it is cut up into convenient sized blocks and piled up ready for market. On the whole, the smaller amount of waste in kiln-dried clay, and the saving of expense for scraping, more than makes up for the expense of fuel, and few modern works are without kilns for drying.

The preparation of the china stone for the market is a much more simple operation. China stone is also a kind of granite, which is, however, only partially decomposed, but it is only valuable when it happens to be free from mica and all other minerals except the quartz and partially decomposed felspar. It occurs chiefly in the parishes of St. Stephens, St. Dennis, and Breage, and is often associated with china clay. The rock is simply quarried down, and the joints dressed over where discoloured

with oxide of iron, when it is at once ready for shipment, chiefly to Runcorn. From Runcorn it is sent to the potteries, where it is used with china clay in the manufacture of porcelain and earthenware.

It is not only in the potteries, however, that china clay is used. As stated above, more than 200,000 tons per annum are now exported from the two western counties, the value of which at the present exceptionally low prices may average, perhaps, 1*l.* per ton at the shipping port. Of this large quantity probably little more than one-third is used in the English potteries. Fully as much is used by the paper-makers of the United Kingdom, and probably 20,000 tons are used by makers of alum and sulphate of alumina, and at least as much by "bleachers" of calico and yarn. Many thousands of tons are shipped to the Continent for all the above purposes, and also for the manufacture of ultramarine. So cheap and convenient an article is also no doubt used to a considerable extent by adulterators and sophisticators of various kinds, but it probably only needs to be more widely known to be used legitimately for many purposes to which hitherto it has not been applied.

We have spoken above of the "sand" of the "mica." Nowadays much of the fine mica is re-washed and sold as an inferior "mica clay" for making inferior kinds of paper and pasteboard, but the bulk of it must still be regarded as a waste product. The sand is also largely a waste product, and as there are from three to eight tons of sand yielded for each ton of clay, large accumulations exist at most of the principal works. Of late years some of this—mixed with refuse clay—has been made into excellent fire bricks, for which there is a considerable demand, especially for the copper-smelting furnaces of Chili and Mexico; but there are still millions of tons available when a proper use can be discovered.

Very good building bricks have also been made from the discoloured clay and mica, but the heavy cost of carriage usually prevents the use of building bricks at great distances from the place of manufacture, so that, although there is a fair local demand, millions of tons of material are still available for any suitable purpose which may be hereafter discovered.

Some of the sand is very coarse, some very fine—but in all cases it consists mainly of angular fragments of quartz, admirably adapted from their extreme sharpness for mixing with cement or lime for making concrete blocks, or with asphalt for pavements.

The coarser varieties also make excellent gravel walks, as the small quantities of clay and mica usually present serve to bind the grains together under foot to form a firm roadway.

The following analyses, selected from the writer's paper read

to the Royal Geological Society of Cornwall in 1876, fairly represent the composition of average specimens of the materials described above.

	China Clay	China Stone	Mica Clay	Coarse Mica	Sand
Silica	45·40	71·66	46·70	56·41	81·50
Alumina	40·30	18·79	35·20	29.60	13·40
Lime	trace	1·70	trace	—	—
Magnesia	trace	0·35	—	—	—
Peroxide of iron . .	0·20	trace	1·90	2·72	2·50
Alkalies, insoluble and loss	0·60	6·60*	4·66	4·37	0·10
Fluorine	trace	0·14	trace	trace	trace
Oxide of manganese . .	—	trace	—	trace	—
Water	13·50	0·91	11·54	6·90	2·50
	100·00	100·15	100·0C	100·00	100·00

All the older writers speak of "Talc," "Talcose granite," "Protogine," &c., as being abundant in Cornwall and elsewhere. Even Mr. J. A. Phillips, writing in 1875, says: "In some districts mica is replaced by a talc-like mineral, and the granite rock itself passes into protogine." What there may be elsewhere I am unable to say, but there is certainly nothing of the kind known at present in Cornwall. From the whole of the granite districts of Cornwall and Devon talc seems to be entirely absent, and magnesia generally is an extremely scarce substance.

The number of china clay works at present in operation in Cornwall and West Devon is little short of 200, and of course the conditions of working vary considerably in different localities and under different conditions. In some, a little washing only is done during the winter months by means of a small natural stream of water, the total annual produce being only a few hundred tons; in others, valuable machinery and extensive buildings enable the proprietors to turn out nine or ten thousand tons in the same time; but in the main the description given above as fairly describes the occurrence and preparation of china clay and china stone as is possible within the limits of such an article as the present.

The trade at present is much depressed—mainly, I believe, owing to the slackness on the part of those (potters, paper-makers, bleachers, and others) who use clay; but partly, perhaps, owing to the over-production of a few years since. In consequence of this the prices have fallen more than 30 per cent. during the last five years, and the quantities produced have also shown a

* Chiefly potash.

considerable falling off. With the general revival of Englis trade—whenever that may take place—no doubt this branc will also revive.*

* The following table—compiled from Mr. Hunt's Mineral Statistics—shows the variations of production (in tons) since the year 1874, when th largest quantities were produced:—

	China Clay		China Stone	Total
	Cornwall	Devon		
1874 . . .	150,500	33,309	42,500	226,309
1875 . . .	108,250	29,146	38,000	175,396
1876 . . .	105,275	25,000	34,500	164,775
1877 (estimated) .	100,000	22,000	30,000	152,000

THE EXTINCT BRITISH WOLF.

By J. E. HARTING, F.L.S., F.Z.S.

(*Continued from* p. 61.)

PERIOD from the Conquest to the reign of Henry VII.—Historical evidence of the existence of wolves in Great Britain before the Norman Conquest, as might be expected, is meagre and unsatisfactory, and the abundance of these animals in our islands prior to that date is chiefly to be inferred from the measures which in later times were devised for their destruction.

The *Carmen de Bello Hastingensi* (v. 571) states that William the Conqueror left the dead bodies of the English upon the battlefield to be devoured by worms, wolves, birds, and dogs —*vermibus, atque lupis, avibus, canibusque voranda.*

In 1076 Robert de Umfraville,* Knight, lord of Toures and Tain, otherwise called "Robert with the beard," being kinsman to that king, obtained from him a grant of the lordship, valley, and forest of Riddesdale, in the county of Northumberland, with all castles, manors, lands, woods, pastures, waters, pools, and royal franchises which were formerly possessed by Mildred, the son of Akman, late lord of Riddesdale, and which came to that king upon his conquest of England; to hold by the service of defending that part of the country for ever from enemies *and wolves*, with the sword which King William had by his side when he entered Northumberland.†

1087–1100. The inveterate love of the chase possessed by William Rufus, which prompted him to enforce, during his tragical reign, the most stringent and cruel forest laws, is too well known to readers of history to require comment. It can-

* "The name seems to be derived from one of the several places in Normandy now called Amfreville, but in some instances originally Omfreville, that is *Humfredi villa*, the vill or abode of Humphrey."—Lower, "Patronymica Britannica."

† See Dugdale's "Baronage," vol. i. p. 504, and Blount's "Ancient Tenures," p. 241.

not be doubted that in the vast forests* which then covered the greater part of the country, and through which he continuously hunted, he must have encountered and slain many a wolf. Yet, strange to say, a careful search through a great number of volumes has resulted in a failure to discover any evidence upon this point, or indeed any mention of the wolf in connection with this monarch.

Longstaffe, in his account of "Durham before the Conquest," states that a great increase of wolves took place in Richmondshire during this century, and mentions incidentally that Richard Ingeniator dealing with property at Wolviston (called Olveston in the time of William Rufus) sealed the grant with an impression of a wolf.

1100–1135. In his passion for hunting wild animals, Henry I. excelled even his brother William, and not content with encountering and slaying those which, like the wolf and the wild boar, were at that time indigenous to this country, he "cherished of set purpose sundrie kinds of wild beasts, as bears, libards, ounces, lions, at Woodstocke and one or two other places in England, which he walled about with hard stone An. 1120, and where he would often fight with some one of them hand to hand." †

1156. There can be no doubt that at this period, and for some time afterwards, the New Forest as well as the Forest of Bere, in Hampshire, both favourite hunting grounds with William Rufus and his brother Henry, were the strongholds of the wolf, as they were of the wild boar and the red deer, for in the second year of the reign of Henry II. the Sheriff of Hants had an allowance made to him in the Exchequer for several sums by him disbursed for the livery of the King's *wolf-hunters*, hawkers, falconers, and other things. "*Et in liberatione lupariorum* 100*s*., *et in liberatione accipitrariorum et falconariorum Regis* 22*li. per Willelmum Cumin.*" ‡

In the fourth year of the same reign, the Sheriffs of London were allowed by the Chancellor 40*s*. out of the Exchequer for the King's huntsmen and his dogs. "*Et venatoribus Regis et canibus ejus* xl^{s} *per cancellarium.*" §

* "The word 'forest,' in its original and most extended sense, implied a tract of land lying out (*foras*), that is, rejected, as of no value, in the first distribution of property."—Whitaker, "History of Whalley," p. 193.

† Harrison's Description of England, prefixed to Holinshed's "Chronicle," p. 226.

‡ Madox, "History and Antiquities of the Exchequer of the Kings of England from the Norman Conquest to the end of the Reign of Edward II.," vol. i. p. 204 (1769).

§ Madox, tom. cit. p. 207.

Conan, Duke of Brittany and Earl of Richmond, in 1164, granted, amongst other privileges, to the Abbey of Jourvaulx, several pastures on the north side of the river Jore, reserving only liberty for his deer, likewise pasturage throughout his new forest, near Richmond, Yorkshire, for all their cattle, with power to keep hounds for chasing wolves out of those their territories.*

In 1167, the Bishopric of Hereford was vested in the King in consequence of the see being then vacant; and in the account of John Cumin, who acted in the capacity of Custos, we find in the accounts of the revenue and expenditure of the temporalities a payment of 10*s.* for three wolves captured that year. "*Et pro tribus Lupis capiendis, x*^{s}."

William Beriwere obtained from Henry II. the confirmation of all his lands, as also the forestership of the Forest of De la Bere, with power to take any person transgressing therein between the bars of Hampton and the gates of Winchester, and likewise between the river of Ramsey and the river of Winchester to the sea, as amply as his father had held the same in the times of King William and King Henry I. From Richard I. (whom he accompanied to the Holy Land, and whom he was instrumental in delivering from prison when that King was confined in Germany) he obtained many valuable emoluments as well as large territorial grants, and in the following reign was no less fortunate with King John, who, having a great regard for him in consequence of his knowledge in the art and mysteries of venery, gave him license to enclose his woods at Joare, Cadelegh, Raddon, Ailesberie, and Burgh Walter, with free liberty to hunt the hare, fox, cat, and *wolf*, throughout all Devonshire, and likewise the goat beyond the precincts of the forest; and to have free warren throughout all his own lands for hares, pheasants, and partridges.†

From a charter of liberties granted by King John, when Earl of Morton, to the inhabitants of Devonshire, it appears that the wolf was at that time included amongst the "beasts of venery" in that county. The original deed, which is still preserved in the custody of the Dean and Chapter of Exeter, is under seal, and provides *inter alia* as follows:—"*Quod habeant canes suos et alias libertates, sicut melius et liberius illas habuerunt tempore ejusd. Henrici regis et reisellos suos, et quod capiant capreolum, vulpem, cattum, lupum, leporem, lutram, ubicunque illa invenirent extra regardum forestæ meæ.*"‡

* Dugdale's "Baronage," vol. i. p. 48. Ex Regist. Archiep. Cant. p. 875*a*.

† Dugdale's "Baronage," vol. i. p. 701; Curt. Antry. H. n. 16.

‡ Ex Autographo penes Dec. et. Capit. Exon. From Bp. Lyttelton's Collections. Quoted by Pennant, "British Zoology," vol. ii. p. 308 (1812).

1209. Mr. Evelyn P. Shirley has printed * two deeds of the 10th of John relating to the manor of Henwick, in the parish of Bulwick, county Northampton, held by the tenure of hunting the wolf (*jugacum lupi*), and he suggests that from this tenure probably the family of Luvet or Lovett, originally of Rushton, and afterwards of Astwell, in the county of Northampton, bore for their arms: Argent, three wolves passant in pale sable, armed and langued gules.†

1212. In this year, when the neighbourhood around Kingsclere was all forest, we find an entry in the Patent Rolls of a payment of 5*s.* as a reward for the capture of a wolf at Freemantle.‡

Amongst the entries in the *Rotulus Misæ, anni Regis Johannis quartodecimi* (1212–1213), are the following, which relate to the capture or chase of the wolf:—

"On Thursday next in the octave of the Holy Trinity [May 12], for a wolf captured at Freemantle [Surrey] by the dogs of Master Ernald de Auclent, 5*s.*"

"*Item.* [at Hereford]. Thursday next following the Feast of St. Martin [Nov. 22] to Norman the keeper of the Veltrars,§ and to Wilkin Dogget, his associate, for two wolves captured in the forest of Irwell, 10*s.*, by the King's command, &c."

"*Item.* Wednesday next following the feast of St. Gregory [March 12], for two wolves captured, one at Boscha de Furchiis, the other at Willes, 10*s.*, given to Smalobbe and Wilck, the keepers of the veltrariõ of Thomas de Sanford."

It is perhaps not generally known that the circumstance narrated in the story of Bedd Gêlert, with which every one is familiar, is said to have occurred in the reign of King John, and, as it is a story of a British wolf, it is scarcely to be passed over here without some brief notice, the more so as it is not at all unlikely that it is founded on fact.

The tradition, as related by Bingley in his "Tour round North Wales," ‖ is to the effect that Llewellyn, who was Prince of Wales in the reign of King John, resided at the foot of Snowdon, and, amongst a number of other hounds which he possessed, had one of rare excellence which had been given to him by the King. On one occasion, during the absence of the

* "Collectanea Topographica et Genealogica," vol. vi. p. 299.

† The wolf frequently appears on heraldic bearings, as we shall have occasion to notice more particularly later on.

‡ Patent Rolls, May 31, 1212, quoted in "Sussex Archæological Collections," xxiv. p. 161.

§ *Veltrarius*, or *vautrarius*, from the French *vaultre*, was a mongrel hound for the chase of the wild boar. Blount, "Ancient Tenures," p. 233.

‖ "A Tour round North Wales," 1800, vol. i. p. 363.

family, a wolf entered the house; and Llewellyn, who first returned, was met at the door by his favourite dog, who came out, covered with blood, to greet his master. The prince, alarmed, ran into the house, to find his child's cradle overturned, and the ground flowing with blood. In a moment of terror, imagining that the dog had killed the child, he plunged his sword into his body, and laid him dead on the spot. But, on turning up the cradle, he found his boy alive and sleeping by the side of the dead wolf. This circumstance had such an effect on the mind of the prince, that he erected a tomb over the faithful dog's grave on the spot where afterwards the parish church was built, called from this incident Bedd Gêlert, or the grave of Gêlert. From this story was derived the common Welsh proverb, "I repent as much as the man who slew his greyhound."

The dog referred to belonged probably to the race called by Pennant "the Highland gre-hound," of great size and strength, deep-chested, and covered with long rough hair. This kind was much esteemed in former days, and was used for hunting by all the great chieftains in preference to any other. Boethius styles it "*genus venaticum cum celerrimum tum audacissimum.*"

1216–1272. In the following reign of Henry III. wolves were still sufficiently numerous in some parts of the country to induce the King to make grants of land to various individuals upon the express condition of their taking measures to destroy these animals wherever they could be found.

In 1242 it appears that Vitalis Engaine made partition with William de Cantelupe, Baron of Bergavenny, of the manor of Badmundesfield, in Suffolk, as heir to William de Curtenai, and the same year had a summons, amongst divers great men, to attend the King, well appointed with horse and arms, in his expedition into France. He died in 1249, seized, *inter alia*, of part of the lordships of Laxton and Pichesle, in the county of Northampton, held by "petit serjeanty," viz. to hunt the wolf whensoever the King should command.*

Selden, in his notes to Drayton's "Polyolbion" (ix. 76), refers to the manor of Piddlesey in Leicestershire, which was held by one Henry of Angage *per serjeantiam capiendi lupos*, and quotes as his authority Itin. Leicester. 27 Hen. III. in Archiv. Turr. Lond. In the same reign, William de Limeres held of the King *in capite*, in the county of Southampton, one carucate of land in Comelessend by the service of hunting the wolf with the King's dogs.†

* Dugdale's "Baronage," vol. i. p. 466.

† Esc. temp. H. R. fil. R. Johannis. Harl. MS. Brit. Mus. No. 708, p. 8.

1272–1307. In the third year of the reign of Edward I namely in 1275, Sir John d'Engayne, knight, and Elena d'Engayne, his wife, held lands in Pightesley, in the county of Northampton, by the service of hunting the wolf, *for his pleasure*, in that county,* from which it is to be inferred that this animal was then common enough to be hunted for sport, as the fox is now-a-days. Other lands in the same county were held at this time on condition of the tenant finding dogs "for the destruction of wolves" and other animals.† It appears by the Patent Rolls of the 9th year of Edward I. that in 1280 John Giffard of Brymmesfield or Brampfield, was empowered to destroy the wolves in all the King's forests throughout the realm.‡

In 1281, Peter Corbet was commissioned to destroy all the wolves he could find in the counties of Gloucester, Worcester, Hereford, Salop, and Stafford, and the bailiffs in the several counties were directed to be ready and assist him. The commission, which has been frequently referred to by different writers, runs as follows:—

"*Pro Petro Corbet, de lupis capiendis.*

"Rex, omnibus Ballivis, &c. Sciatis quod injunximus dilecto et fideli nostro Petro Corbet quod in omnibus forestis et parcis et aliis locis intra comitatus nostros Gloucester, Wygorn. Hereford, Salop, et Stafford, in quibus *lupi* poterunt inveniri *lupos* cum hominibus, canibus et ingeniis suis capiat et destruat modis omnibus quibus viderit expedire.

"Et ideo vobis mandamus quod idem intendentes et auxiliantes estis.

"Teste rege apud Westm. 14 Maii A.D. 1281." §

In 1285 William de Reynes held two carucates of land at Boyton, in the parish of Finchingfield, in the county of Essex by the serjeanty of keeping for the King five wolfdogs (*canes luporarios*).‖ In the following year John Engaine was returned as holding one carucate of land in Great Gidding, in the county of Huntingdon, by the serjeanty of hunting the wolf, fox, and wild cat, and driving away all vermin out of the forest of the King in that county.¶ About the same time Richard Engain

* Plac. Coron. 3 Edw. I. Rot. 20, *dorso*. Blount, "Ancient Tenures," p. 230.

† Camden, "Britannia," p. 525, and Blount, p. 257.

‡ Calend. Rot. Pat. 40. See also Rymer's "Fœdera," *sub anno*.

§ Cf. Rymer's "Fœdera," i. pt. 2, p. 192; ii. p. 168.

‖ Plac. Coron. 13 Edw. I. Essex; Blount, "Ancient Tenures," p. 236.

¶ Plac. Coron. 14 Edw. I. Rot. 7, *dorso*; Blount, p. 230.

eld one hundred shillings of land in the town of Guedding, in he county of Cambridge, by the serjeanty of taking wolves, nd he was to do this service *daily* (*et facit servic' suum otidie*),* from which it may be inferred that wolves at this date were particularly troublesome.

In 1297 John Engaine died, seized, *inter alia*, of certain lands in Pytesle, Northampton, found to be held of the King by the service of hunting the wolf, fox [cat], badger [wild boar, and hare]; and likewise the manor of Great Gidding in Com, Huntendon, held by the service of catching the hare, fox, cat, and wolf within the counties of Huntendon, Northampton, Buckingham, and Roteland.†

In the accounts of Bolton Priory, quoted in Whitaker's "History of Craven" (p. 331) occur entries in the years 1306–1307, of payments made in reward for the slaughter of wolves, as "*Cuidam qui occidit lupum*," but the price paid to the slayer is not stated.

1307–1327. In the fourth year of Edward II. (1311) a composition was made between Sir John de Mowbray, son and heir of Sir Roger de Mowbray, of the one part, and the Abbot of Selby of the other part, whereby the said Sir John quitclaimed and released to the Abbot all his right in the soil and manor of Crowle and other places therein mentioned, and the Abbot and convent granted to the said Sir John de Mowbray certain woods, saving their free warren of goats, foxes, wolves, conies, &c.‡

The King's forest of the Peak in Derbyshire was of great extent, and about this time was much infested with wolves. A family of the hereditary name of Wolfhunt held lands by the service of keeping the forest clear of these destructive animals.§ From the records in the Tower of London (13 Edw. II.) it appears that in 1320 some persons held lands at Wormhill, in he county of Derby, by the service of hunting and taking wolves, from whence they were called Wolfhunt or Wolvehunt.

Mr. W. H. G. Bagshawe, of Ford Hall, Chapel-en-le-Frith, Derbyshire, a descendant of the same family as Mr. F. W. Bagshawe, the present owner of Wormhill Hall, in reply to

* Testa de Nevil, p. 358; Blount, p. 262.

† Dugdale's "Baronage," vol. i. p. 466. See also the *Rotuli Hundredorum*, i. p. 627.

‡ Burton, "Monasticon Eboracense," p. 389. The Abbots of Selby and of St. Mary, at York, were the only two mitred abbots in Yorkshire.

§ "The Local Laws, Courts, and Customs of Derbyshire," Journ. Brit. Archæol. Assoc. vol. vii. p. 197.

inquiries on the subject, has been good enough to write as follows:—

"With the particulars in Blount's 'Tenures' I have long been familiar, but I am sorry to say that I cannot add to them. Wormhill Hall was never, so far as I know, held under the tenure of destroying wolves, but it is most probable that a portion of the lands there were originally held by the tenure of preserving the King's 'verte and venyson' in his forest of the Peak.

"There is a tradition that the last wolf in England was killed at Wormhill, but I never saw any evidence of it, nor did I ever hear any date assigned.

"In my pedigree of our family I find a note to the effect that John de l'Hall (the ancestor of John de l'Hall whose daughter Alice was the wife of Nicholas Bagshawe) was appointed a forester (of fee, I suppose) to the King by deed dated 1349."*

1327–1377. So far as can be gathered from history, it would seem that while stringent measures were being devised for the destruction of wolves in all or most of the inhabited districts which they frequented, in the less populous and more remote parts of the country steps were taken by such of the principal landowners as were fond of hunting to secure their own participation in the sport of finding and killing them.

In Edward III.'s time, Conan, Duke of Brittany, in 1342, gave pasture for cattle through all his new forest at Richmond in Yorkshire to the inmates of the Abbey of Fors in Wensleydale, forbidding them to use any mastiffs to drive the wolves from their pastures.†

In the same year, Alan, Earl of Brittany, gave them common of pasture through all his forest of Wandesley-dale; and to cut as much grass for hay as they might have occasion for, and also gave them leave to take such materials out of the said forest to build their houses, and for other uses; and such iron and lead as the monks found they might apply to their own use; and if the monks or their servants found any flesh of wild beasts in the forest, *killed by wolves*, they might take it to their own use.‡

In 1348, we find that Alan, son and heir of Walter de Wulfhunte, paid a fine to the King of 2*s.* 4*d.* for his relief in respect

* Camden, "Britannia," tit. Derbyshire, i. p. 591; Blount, "Ancient Tenures," p. 250.

† Escheat, 15 & 16 Edw. III. no. 76, in Turr. Lond. See also Burton, "Monasticon Eboracense," p. 370. The Abbey of Fors, in Wensleydale, was founded in 1145 (Whitaker).

‡ Burton, loc. cit.

of lands at Mansfield Woodhouse, in the county of Nottingham, which he held by the service of hunting wolves out of the forest of Shirewood, if he should find any of them.*

Thomas Engaine, dying without issue in 1368, was found to be seized of 14 yardlands and meadow, and 14*s.* 4*d.* rent, in Pightesle, in the county of Northampton, held by the service of finding, at his own proper costs, certain dogs for the destruction of wolves, foxes, martens, cats, and other vermin within the counties of Northampton, Roteland, Oxford, Essex, and Buckingham.†

Passing over the reign of Richard II. (1377–1399), during which we have not met with any particular mention of wolves in England, we come to that of Henry IV.

1399–1413. In this reign Sir Thomas de Aylesbury, knight, and Catharine his wife, held of the King, *in capite*, the manor of Laxton, *inter alia*, with the appurtenances in the county of Northampton, by "grand serjeanty"—viz., by the service of taking wolves, foxes, wild cats, and other vermin in the counties of Northampton, Rutland, Oxford, Essex, Huntingdon, and Buckingham.‡

Shakespeare has pictured wolves as existing in Kent in the time of Henry VI. When the Duke of Suffolk lands at night upon the shore near Dover, he hears

> "Loud howling wolves arouse the jades
> That drag the tragic melancholy night."
> 2 Hen. VI. act. iv. sc. 1.

This may or may not be a poetic license. At all events, no evidence on the subject is now forthcoming, and we must turn, therefore, to some more reliable source of information.

1422–1461. In the eleventh year of Henry VI. (1433), Sir Robert Plumpton, knight, was seized of one bovate of land in Mansfield Woodhouse, in the county of Nottingham, called Wolf-hunt land, held by the service of winding a horn and chasing or frightening the wolves in the forest of Shirewood.§ This tenure is particularly referred to by the Rev. Samuel Pegge in his paper "On the Horn as a Charter or Instrument of Conveyance."‖ A coloured plate of an ancient horn of the kind re-

* De termino Trin. anno 21 Edw. III. Rot. 1. Harl. MS. Brit. Mus. No. 34, p. 166. Blount, "Ancient Tenures," p. 258.

† Rot. fin. 42 Edw. III. m. 13. Dugdale's "Baronage," vol. i. p. 467; and Blount, "Ancient Tenures," p. 231.

‡ Blount, op. cit. p. 260.

§ Escaet. 11 Hen. VI. n. 5. Blount, p. 312.

‖ "Archæologia," vol. iii. p. 3. See also Thoroton, "Antiq. Nottingham." p. 273, and Strutt, "Sports and Pastimes," p. 19.

ferred to, in the possession of the late Lord Ribblesdale, will be found in Whitaker's "History and Antiquities of the Deanery of Craven" (1805), p. 34.

In the seventeenth year of the reign of Henry VI., namely, in 1439, Robert Umfraville, a descendant, no doubt, of the Robert de Umfraville mentioned in 1076, held the castle of Herbotell and manor of Otterburn, of the King, *in capite*, by the service of keeping the valley and liberty of Riddesdale, where the said castle and manor are situated, free from wolves and robbers.*

1461–1483. If no particular mention of wolves is to be met with in the days of Edward IV., his reign would nevertheless deserve mention here from the fact that at this period lived Juliana Barnes, or Berners, a lady of an ancient and illustrious house, who was commonly styled the Diana of her age, and writ divers treatises on Hunting, Hawking, Fishing, and Heraldry.†

In her "Boke of St. Albans," 1480, she includes the wolf amongst the beasts of venery, and thus instructs her readers on the subject:—

> "My dere sones wher ye fare by frith or by fell
> Take gode hede in hys tyme how Tristram ‡ will tell
> Four maner Bestes of Venery there are:
> The first of hem is a Hart, the second is an Hare,
> The Boor is one of tho,
> The Wolf and no mo."

1485–1509. Some time between these two dates, during the reign of Henry VII., it is probable that the wolf became finally extirpated in England, although for nearly two centuries later, as will presently appear, it continued to hold out against its persecutors in Scotland and Ireland. That it was rare if not quite extinct in England about this time, may be inferred from the circumstance that little or no mention is made of it either in this or any subsequent reign. We are aware that Professor Newton, in his "Zoology of Ancient Europe," has stated (p. 24) that the wolf was found in the North of England in the reign of Henry VIII., a statement which has been also advanced or copied by other writers,§ but we have not met with any proof of this. Indeed, Professor Newton has lately been good enough to inform us that he has forgotten his authority for the state-

* Madox, "Baronia Anglica," p. 244.

† Longstaffe, "Memoirs of the Life of Ambrose Barnes" (Surtees Society), 1867, p. 27.

‡ Manwood, in his "Forest Laws," mentions "Sir Tristram, an ancient forester, in his worthy treatise of hunting."

§ Wise's "New Forest, its History and its Scenery," p. 14.

ment and thinks it possible a reference to the MS. of his essay, which was not preserved, would show that, by a typographical error, the numerals VIII. were printed for VII.

In Longstaffe's "Memoirs of the Life of Ambrose Barnes," * it is stated that "his immediate ancestors held an estate of 500*l.* a year of the Earls of Rutland and Belvoir, one of whom (a Barnes of Hatford near Barnard Castle) was commonly called Ambrose 'Roast Wolf,' from the many wolves which he hunted down and destroyed in the time of Henry VII." †

In a footnote to this passage, the editor remarks that "the statement must be taken *cum grano salis*. Belvoir is not a title, and the Manners family did not become Earls of Rutland until 1525, in the reign of Henry VIII.‡ On the other hand, the period of Henry VII. is late for wolves, although Richmondshire might well yield some of the latest specimens in England. Doubtless they were familiarly associated with wildness of country long after their extinction. Many a tradition would linger in the families of their destroyers. Ambrose 'Roast Wolf' was probably a real person of some date or other."

Within the precincts of Savernake Forest, the property of the Marquis of Ailesbury, near Marlborough, there is still existing a very old barn and part of a house, known as "Wolf Hall." It was the ancient residence of the Seymours, and when Henry VIII. married Lady Jane Seymour it was here that he came a-courting, here that Queen Jane Seymour was married, and in this barn the wedding festivities are said to have taken place. In reply to our inquiry whether any tradition exists in the county to explain the name "Wolf Hall," the Rev. A. C. Smith, of Yatesbury Rectory, Calne, has obligingly written as follows:—"It is supposed by some to have had nothing to do with the animal 'wolf,' but rather with 'Ulf,' the owner's name, if there was such a person, and in the Domesday record it is spelt 'Ulfhall.' At the same time I must add that Leland in his Itinerary (ix. 36) calls it in Latin '*Lupinum villa splendida*,' and again in his poem on the birth of the Prince of Wales, afterwards King Edward VI.,§ '*Incoluit villam, quæ nomine dicta Lupinum.*' Bishop Turner also (Bibl. Brit.

* "Memoirs of the Life of Mr. Ambrose Barnes, late Merchant and sometime Alderman of Newcastle-upon-Tyne," p. 28. (Surtees Society, 1867.)

† See also Longstaffe's "Durham before the Conquest," p. 49.

‡ It is possible that a typographical error may have been made here also, and that Ambrose "Roast Wolf" may have lived in the reign of Henry VIII., not Henry VII.

§ Leland, "Genethliacon illustrissimi Eduardi Principis Cambriæ," &c. 1543.

Hibern.) speaks of certain epistles written by Edward, the future Protector, son of John Seymour, '*de Puteo Lupino, vulgo Wolf-hall.*' So I am not so certain that the derivation is not from the animal. At all events, it is quite clear that no place could be more fitted for wolves than the wild extensive forest of Savernake hard by: indeed, if wolves existed at all in England now, that would be just the very harbour for them."

Many names of places compounded with "wolf" still remain to attest probably the former existence of this animal in the neighbourhood. Wolmer, *i.e.* Wolfmere or Wolvemere, is an instance of this. Wolferton is another. Reginaldus, in the twelfth century, variously translates Wolsingham into the dwelling of Ulsus, the habitation of a wolf, and the howling of a wolf, expressed in the English tongue. So Symeon has "*Ulfswelle, id est fons lupi.*" *

Wolfenden in Rossendale, and Wolfstones in Cliviger (Lancashire), both attest the existence of this animal there when those names were imposed.† Many other instances, no doubt, might be adduced. In the parish of Beckermont, Cumberland, is a small hill, commonly called "Wotobank." A traditionary story, of great antiquity, says that a lord of Beckermont and his lady and servants were one time hunting the wolf; during the chase this lord missed his lady; after a long and painful search, they at last, to his inexpressible sorrow, found her body lying on this hill or bank, slain by a wolf, and the ravenous beast in the very act of tearing it to pieces, till frightened by the dogs. In the first transports of his grief the first words that he uttered were "Woe to this bank!" since which time it has been commonly called "Wotobank." ‡

In Lancashire, Dr. Whitaker particularly mentions the great forests of Blackburnshire and Bowland as "among the last retreats of the wolf." §

The "wolds" of Yorkshire appear, from the dates of parish books, to have been infested with wolves perhaps later than any other part of England.

"In the entries at Flixton, Hackston, and Folkston, in the

* Longstaffe, "Durham before the Conquest," p. 49.

† Whitaker, "History of Whalley," i. p. 74. "The first mention of Rossendale by name is in the memorable story of Liwlphus, dean of Whalley, who, at a place called Ledmesgreve, cut off the tail of a wolf in hunting" (tom. cit. p. 316).

‡ Hutchinson, "Hist. and Antiq. Cumberland," (1794) vol. ii. p. 16. Upon this tradition was founded an "elegant elegiac tale" by Mrs. Cowley, which will be found prefixed to the second volume of the work quoted.

§ Op. cit. i. p. 205. The last herd of red deer was destroyed there in 1805.

East Riding of Yorkshire," says Blaine, "are still to be seen memoranda of payments made for the destruction of wolves at a certain rate per head. They used to breed in the 'cars' below, amongst the rushes, furze, and bogs, and in the night time to come up from their dens; and, unless the sheep had been previously driven into the town, or the shepherds were indefatigably vigilant, great numbers were sure to be destroyed." *

Apparently, however, some error has been made in the orthography of the localities referred to. Flixton is in the parish of Folkton, near Scarboro'. We cannot find that there is any such place as Hackston, but Staxton adjoins the other places named, and is in the parish of Willerby. The Vicar of Willerby, the Rev. G. Day, at our request has most obligingly instituted a search, but has not succeeded in finding any parish-books of any kind to throw light on the subject. He writes: "There are no gentry resident in this parish, and the churchwardens have been tenant-farmers for generations. Of course great changes have occurred within the last, say, fifty years, amongst these tenant-farmers. Many names have altogether disappeared from the parish roll, and it is thought probable by some of the old farmers here that churchwardens in past days having left their farms and gone to other parishes took the parish books with them, and that these have either been destroyed or are lying hid in some descendant's lumber-room."

In a paper "On Druidical Remains in the Parish of Halifax, Yorkshire," by the Rev. John Watson, M.A., F.S.A.,† the author says that "in the township of Barkisland is a small ring of stones, now called (1771) by the name of the *wolf-fold*. It is but a few yards in diameter, but the exact measurement of it I have lost or mislaid.

"The stones of which it consists are not erect, but lie in a confused heap like the ruins of a building. This place I took at first, from its name, to have been either a decoy for the taking of wolves, or a place to secure them in for the purpose of hunting; but observing that Mr. Borlase (p. 198) has attributed some such little cirques to the Druids, I have mentioned it here for the further examination of antiquaries, who are desired to take notice that if ever there was a wall here of any strength, the best stones must have been carried away; for what are left are extremely rude, and totally unfit of themselves to compose any sort of building; also that these few insignificant pebbles, as they now appear, must be of considerable antiquity, as well as once have been of considerable account, because they give

* Blaine's 'Encyclop. Rural Sports' (1858), p. 105.
† Archæologia, vol. ii. p. 355.

the name of Ringstone Edge to a large tract of land aroun them."

The late Wm. Hamper, F.S.A., in some learned observation on certain ancient pillars of memorial called Hoar Stone (Archæologia, xxv.), gives a list of such as were known to hin and, in particular, mentions (p. 53) the *wolf-stone*, a singl merestone, one immense natural block on Dr. Whitaker's estat which, in all probability, was erected to commemorate som notable slaughter of wolves in days gone by.

[*To be continued.*]

THE LIQUEFACTION AND SOLIDIFICATION OF AIR AND HYDROGEN.

By W. N. HARTLEY, F.R.S.E., King's College, London.

In a former article in the "Popular Science Review" (April 1877), it was found necessary to give a sketch of the researches of Faraday and others on the liquefaction of gases; and of Cagniard de la Tour and of Professor Andrews on the liquid and gaseous conditions of matter. According to the investigations of those observers a gas is nothing more than a highly attenuated vapour, and therefore capable of liquefaction. As, however, the hitherto possible deviations from the atmospheric temperature and pressure are insufficient to cause a change of state in many of these bodies, they have received the name of permanent gases. The distinction between a gas and a vapour is purely arbitrary. Ether in the gaseous state is called a vapour, while sulphurous acid is called a gas. They are, however, both the vapours of liquids which boil at + 35° C. (95° F.) and −10° C. (14° F) respectively.

In a recent article in the "Chemical News" M. Raoul Pictet has very concisely stated the conditions to be fulfilled before we may hope to bring the molecules of a gas into such close contact with each other that they may cohere to form a liquid:—

1. The gas must be absolutely pure, with no trace of a foreign gas.

2. A means of obtaining enormous pressures must be available.

3. A means of producing intense cold and subtracting heat at these low temperatures.

4. The utilization of a large surface for condensation at these low temperatures.

5. A means of utilizing the rapid expansion of the gas from extreme condensation to the atmospheric pressure—an expansion which, added to the preceding means, will *compel* liquefaction.

"Having fulfilled these five conditions, we may formulate the following alternative:—When a gas is compressed to 500 or

600 atmospheres, and kept at a temperature of — 100° C. or —140° C. (— 148° F. — 220° F.), and it is allowed to expand to the atmospheric pressure, one of two things takes place: either the gas, obeying the force of cohesion, liquefies, and yields its heat of condensation to the portion of the gas which expands and loses itself in the gaseous form; or, on the hypothesis that cohesion is not a general law, the gas must pass to the absolute zero and become inert; that is to say, an impalpable powder. The work done by expansion will not be possible, and the loss of heat will be absolute."

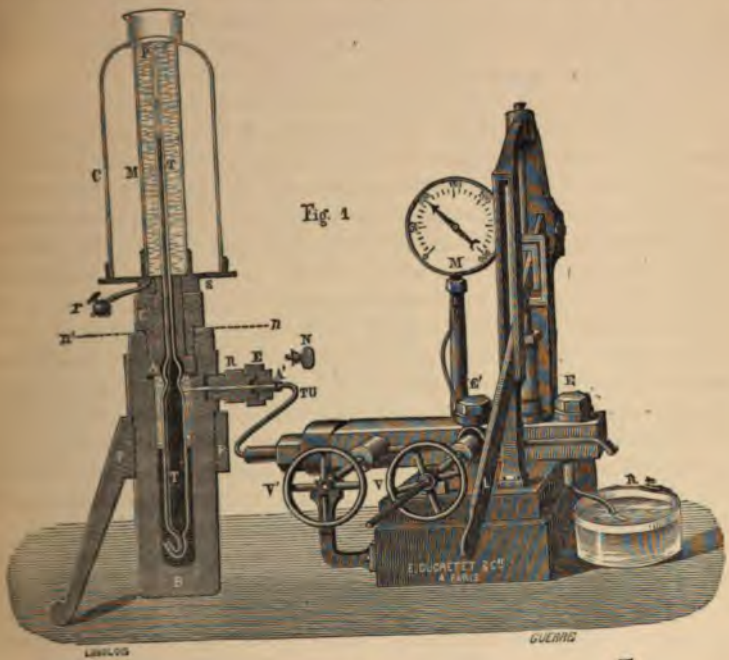
Struck with the truth of this alternative, which is rendered certain by thermo-dynamic equations, based upon accurate data, M. Pictet devised a mechanical arrangement which entirely satisfies these various conditions, and which has been the means of experimentally demonstrating the fact that molecular *cohesion* is a general property of bodies, to which there is no exception. While M. Pictet, of Geneva, has been engaged for more than three years with the solution of this problem, M. Cailletet, of Châtillon-sur-Seine, has devised an apparatus for the same purpose. This very beautiful instrument of M. Cailletet has been the first to compel the liquefaction of a so-called permanent gas, viz., nitric oxide. There soon followed a simultaneous liquefaction of oxygen by both experimenters. While, however, M. Cailletet obtains a visible indication of liquefaction with his instrument, M. Pictet produces a stream of liquid which may be submitted to examination.

M. Cailletet's Apparatus.—There are two forms of this instrument both the same in principle, the large one in use at Châtillon-sur-Seine; and a smaller and very portable apparatus, constructed by M. Ducretet, of Paris, of which fig. 1 is a representation.

The gas to be compressed is contained in the glass tube (T T), the lower end of which is plunged into mercury, contained in the cistern (B), which is constructed by boring out a block of wrought iron so as to leave it as a cylinder with very thick walls. The lower point of the glass tube is curved, and in the bend a little mercury is placed, to keep out atmospheric air and prevent the escape of any gas before the tube is fixed in its place. The upper part of (T) is visible, and is surrounded by a jacket (M), containing a refrigerating liquid, such as liquid sulphurous acid, liquid nitrous oxide, or even iced water. Around the jacket (M) is placed a bell-jar (C), which contains some desiccating material, such as oil of vitriol or chloride of calcium, to dry the air, and so prevent the formation of a dew or deposition of hoar-frost on the glass. Should the tube break, these surrounding vessels would prevent any dangerous result. The compression in this instrument is obtained by hydraulic power, while

in the larger one in use at Châtillon-sur-Seine it is effected by a screw press.

The lever (L) when put in action is capable of giving a pressure of about 300 atmospheres, as indicated by the manometer (M). In order to increase this pressure the flywheel (V) is used, which acts upon a lateral screw plunger, capable of giving a pressure



A PORTABLE FORM OF CAILLETET'S APPARATUS FOR THE LIQUEFACTION OF GASES. SCALE $\frac{1}{5}$. (From "La Nature.")

of 500 atmospheres. The second flywheel (V') serves to relieve the pressure with rapidity and cause a sudden expansion, a means whereby a lowering of the temperature of the gas contained in the tube may be effected to an extent of 200° C. (360° F.). This is the main advantage and peculiarity of M. Cailletet's instrument.

The tube (T T) is shown in fig. 2, detached from the cistern, for the purpose of being filled with the gas to be experimented upon. The apparatus for producing the gas is attached to the

[illegible] When [illegible] completely expelled the point of the tube is [illegible] and the [illegible] of mercury is made to [illegible] the [illegible] of the tube by simply raising the opposite [illegible]. The [illegible] tube is then detached, the [illegible] immersed in the basin of mercury, [illegible] and submitted to pressure. It is [illegible] acting on [illegible] which produces the latter [illegible]. Pressures are measured by the manometer M'.

The Liquefaction of Oxygen.—On December 16 last M. Cailletet gave experimental evidence of the liquefaction of oxygen at the École Normale, in Paris. At a temperature of −23° C. (−20° F.), and under a pressure of 270 atmospheres, it was seen in the gaseous state; but under the influence of a sudden expansion, which lowers the temperature about 200° C. (360° F.), a cloud of mist is produced within the tube, which can be caused only by the oxygen being cooled below its critical point, and thus assuming the liquid state.

Nitrogen. Pure dry nitrogen, compressed to about 200 atmospheres, at a temperature of + 13° C. (56° F.), if allowed to expand rapidly, condenses in a more complete manner; it first presents an appearance like that of spray, consisting of drops of an appreciable size, which move from the sides to the centre of the tube, forming a vertical column along its axis. The duration of this appearance is about three seconds.

The experiment was repeated on December 30, in the presence of many *savants*, at the laboratory of the École Normale.

Hydrogen. This substance, which possesses very nearly all the properties of a perfect gas, has been considered by most philosophers as absolutely incondensable. M. Cailletet, in submitting it to the tests which proved so successful with other bodies, failed on several occasions to observe any resulting phenomena. Several repetitions of his experiments on Dec. 31, in presence of MM. Ste. Claire Deville, Berthelot, and Mascart, gave indications of the liquefaction of hydrogen which were convincing to those who witnessed them. Pure hydrogen, under a pressure of 280 atmospheres, when allowed to expand very suddenly, forms an extremely attenuated mist, which instantly disappears. The production of this mist, notwithstanding its extreme subtlety, was regarded as an undoubted proof that a change to the liquid state had been effected.

Air. By the liquefaction of oxygen and nitrogen that of air is already demonstrated; but as it was of interest to actually perform the experiment, a portion of air, dried and freed from acid, was submitted to pressure and subsequent ex-

sansion, and its condensation succeeded as might have been expected.

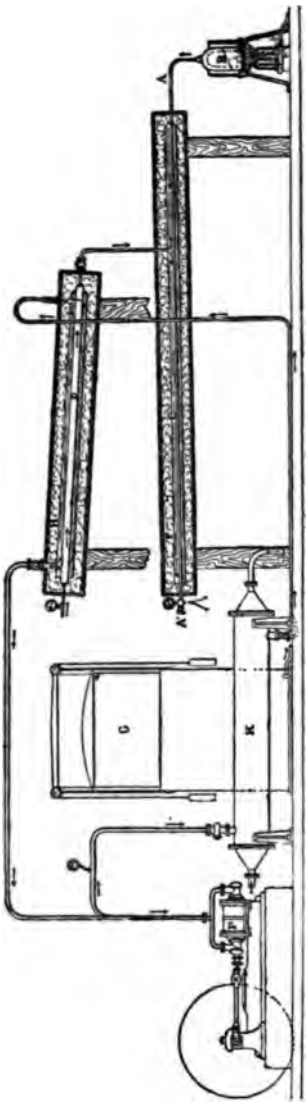
Fig. 3.

M. RAOUL PICTET'S MACHINE FOR THE LIQUEFACTION OF GASES. (From "La Nature.")

M. Pictet's Machine.—In a former number of the "Popular Science Review" (July 1877) the beautiful freezing-machine of

M. Raoul Pictet was described, and its advantages mention will be remembered that intense cold is produced in this m by the evaporation *in vacuo* phurous acid liquefied by pr In continuation, as it were, subject comes the followin scription of the most perfe elaborate refrigerating app capable of withstanding eno pressures, which has hithert constructed. It is the inven M. Pictet, and is a further de ment of his ice-machine.

FIG. 4.



PLAN IN SECTION OF THE SAME.

The accompanying drawing 3 and 4), show the general ar ment of its parts, while som of its very considerable dime may be gained from the fac the manometer near the lette raised from the ground abo height of a man, while the r capable of holding more than persons.

A howitzer shell (B), cont 700 grammes (a pound and a of chlorate of potash, mixe chloride of potassium to mo its decomposition. It is with gas.

(AA', fig. 4.) A tube, over 1 in length, ½ inch external dia and ⅛ inch internal diamet which the oxygen condenses. furnished with a screw-tap from which the liquefied gas st forth. A pressure-gauge me the pressure up to 800 spheres.

(C) A tube, 13 feet in l in which is solid carbonic The stock of carbonic acid i tained in a gasholder (G), 22 lons in capacity. A three-w places it, when desired, in c tion with the apparatus.

A non-conducting covering, with a wooden casing. tube of 2½ inches diameter, and 3 feet 7 inches

containing liquid carbonic acid, compressed by the pumps, and surrounded by liquid sulphurous acid, contained in a tube 5 inches in diameter and 3 feet 7 inches long.

(H) A non-conductor of heat, with a wooden covering.

(K) A tubular condenser for liquid sulphurous acid, compressed by the pumps.

(P) Double-action exhaustion and force pumps; two for drawing carbonic acid either from the tubular condenser or from the gas-holder, according to the position of a three-way cock; the other pair for exhausting sulphurous acid from the tube surrounding D.

The following is a concise description of the working of the apparatus:—A pair of pumps such as are used in the freezing-machine are so coupled that the exhaustion of one corresponds to the compression of the other. The exhaustion of the first pump communicates with the tube enclosed in (H), which contains liquid sulphurous acid. Under the influence of a good vacuum the temperature of this liquid rapidly sinks to −65° C. (−85° F.), or even to −73° (−100° F.), the lowest limit attained. Through this tube of sulphurous acid passes a second smaller one, in which is retained compressed carbonic acid. The carbonic acid, made from hydrochloric acid and Carrara marble, is washed and dried and stored over oil in a gas-holder.

At a pressure of six atmospheres the carbonic acid liquefies under these circumstances. The resulting liquid is passed into the long copper tube (C) (fig. 4).

A pair of pumps are arranged to exhaust carbonic acid either from this tube (C), or from the gas-holder (G). When the carbonic acid vapour is extracted from the tube in which it is contained the liquid solidifies, and its temperature descends to −140° C. (−220° F.). The subtraction of heat is maintained by the working of the pumps, the cylinders of which extract 3 litres, or approaching $\frac{3}{4}$ gallon, per stroke, at a speed of 100 strokes per minute. Both the cooling tubes are covered with a non-conducting material and a casing of wood. Through the interior of the carbonic acid tube passes the long tube (A), proceeding from the iron shell or retort it is over 16 feet in length, with a base of about $\frac{1}{8}$ inch, and walls $\frac{3}{8}$ inch in thickness. Being constantly immersed in solid carbonic acid, the whole surface of the tube is brought to a temperature of −140° C. (−220° F.). The tube is slightly inclined, to allow of liquid collecting at the lower end. The upper end of the tube is curved, and screwed into the howitzer shell (B). The sides of this shell are more than 2 inches in thickness; its height is 18 inches, and its diameter 10 inches.

When oxygen is to be liquefied this shell contains 1½ lbs. of

chlorate of potash and half a pound of chloride of potassium, mixed together, fused, broken up, and placed in the shell perfectly dry. When the double circulation of the sulphurous and carbonic acids has sufficiently lowered the temperature of the apparatus the shell is heated by a series of gas-burners. The disengagement of oxygen takes place at first gradually, and then rather suddenly, near the end of the operation. A pressure-gauge at the end of the tube gives constant indications of the progress of the reaction. The gauge, which is graduated to 800 atmospheres, was made expressly for M. Pictet by Bourdon, of Paris.

At the termination of the reaction the gauge indicates a pressure of 370 atmospheres, which almost immediately sinks and remains at 320 atmospheres. On opening the screw-tap a jet of liquid oxygen is seen to squirt out with extreme violence.

Pieces of charcoal, feebly incandescent, placed in the way of this jet inflame with inconceivable violence. A ray of electric light thrown upon the jet shows it to consist of two parts, one central, and an inch or so in length, the whiteness of which is suggestive of its being the liquid; the external portion has a blue tint indicating that it is probably a congealed mist.

Hydrogen.—On January 10 of the present year M. Pictet succeeded in liquefying, and even solidifying, hydrogen in the laboratories of the Society for the Construction of Physical Instruments at Geneva.

The experiment was performed in the presence of several persons with great success.

The gas was obtained by the process of Berthelot, which yields it in a state of the most perfect purity. The reaction employed consists in decomposing formiate of potassium with caustic potash. At a pressure of 650 atmospheres and a temperature of −140° C. −220° F. there was emitted from the jet when the tap was opened a steel-blue jet, producing a hissing sound like that of a red-hot iron being immersed in water.

The jet suddenly became intermittent, and there succeeded a hail of solid particles, like small shot being projected on to the ground with violence. Their fall produced a harsh, shrill noise or crackling sound.

The tap was closed, and the pressure fell from 370 to 320 atmospheres, at which it remained some minutes. It then rose to 325 atmospheres. On opening the tap a second time only an intermittent jet escaped, rendering it probable that solidification had taken place within the tube. Proof of this was afforded by the fact that when the temperature was allowed to rise by stopping the pumps the escape of hydrogen in the liquid state was resumed.

Pictet has recently found, both by calculation and ex-
ent, that liquid oxygen is identical in density with

, a few short months since and to have talked of being
o solidify hydrogen would have been idle; to have be-
it impossible of accomplishment would have been deemed
ophical.

THE RADIOMETER.

By W. H. STONE, M.B., F.R.C.P.

LECTURER ON PHYSICS AT ST. THOMAS'S HOSPITAL.

WITH the exception of the telephone, no discovery has for many years attracted so much public attention, both in scientific and in general circles, as the radiometer. Nor is this remarkable, if it be considered how perfectly novel and how striking were the phenomena which it for the first time brought to light. A new mine of knowledge seemed to have been opened, and it was matter of speculation as to what further treasures might thus be within our grasp. The crude facts of attraction, repulsion, and rotation were so unexpected, and yet so perfectly obvious, even to unpractised observers, that there is little cause for surprise at the warmth with which their explanation was attempted, and as little at the wildness and conflicting character of many suggestions that were offered. Light, heat, electricity, evaporation and condensation, the molecular constitution of gases, and even less probable hypotheses, all offered specious and plausible modes of accounting for what was an objective reality past denying. There was not even room for incredulity as to the fact; the less, in that the apparatus employed, consisting of a glass tube, a bar of common pith, and an ordinary candle, was so extremely simple. The machine, if indeed it was worthy of that name, went naturally into the category of those apparently trivial but really complex and pregnant combinations of common materials which, when once constructed, have each of them formed a beacon and signal post on the great high road of scientific discovery. That this was exactly the attitude of the scientific mind may be seen from the words used by the President of the Royal Society in presenting the gold medal to the discoverer of the radiometer. "It is," he says, "attending this phenomenon that gives it its great importance. There is evidently some action going on with which we are not at present acquainted, and there is no saying what a thorough investigation of the phenomenon may lead to."

is perhaps not too much to say that in this instrument
ave one of the grandest and purest demonstrations of the
tual movement, the ceaseless flux and reflux, which is
ally going on in nature; an idea stated by the Greek
sopher in the axiom *ῥεῖ πάντα*, reappearing in the vortices
scartes, and of late testified to by many and various ex-
ental acquisitions. Even in a logical point of view, con-
ble interest attaches to the mental process involved in the
pment of the radiometer. The fact of repulsion being
, and its explanation postulated, a rapid method of exclu-
as needed, by means of which the cruder and less con-
t hypotheses could be filtered off. To this the inventor
diately and almost instinctively applied himself; nor would
difficult to trace in successive modifications which the
ment has undergone the *tabula præsentiæ*, the *tabula
tiæ in proximo*, the *tabula graduum*, and the other tests
in Bacon's "Novum Organon" conduce "to a true and legi-
induction, the very key of interpretation." An attempt
e made in the following pages to show that "after an
ion correctly effected, an affirmative form will remain as
siduum, solid, true, and well defined, whilst all volatile
ns go off in smoke." *

this purpose it will be desirable to take a brief survey,
onological order, of the various steps in the evolution of
t and most complete form of the instrument, the otheo-
as they occur in the proceedings of the Royal Society,
Philosophical Magazine," and in one or two foreign
icals.

December 11, 1873, a paper was read by Mr. Crookes,
had been received in the preceding August, of which the
as, "On the Action of Heat on Gravitating Masses."
thor therein stated that the experiments to be recorded
rom observations made when using the vacuum balance,
ermining the atomic weight of thallium, for weighing
ces of a higher temperature than the surrounding air
ights. There appeared to be a diminution of the force
vitation, the experiments being instituted in order to
the action more sensible, and to eliminate sources of

preamble furnishes a historical *résumé* of vague hints
subject given by previous observers. The Rev. A.
, in 1792, recorded the fact that a light substance deli-
suspended in air was attracted by warm bodies; this
ibed to air currents. Laplace spoke of the repulsive
f heat; Libri had made experiments, unsuccessfully
d by Baden Powell; Fresnel obtained contradictory

* *Novum Organon*, Book II. par. xvi.

results with concentrated solar light acting on a fixed and a suspended disc; Saigey described experiments which appeared to prove that marked attraction existed between bodies of different temperatures. Forbes and Faye had also contributed to the subject.

The author then describes various forms of apparatus of increasing delicacy which enabled him to detect and render very sensible an action exerted by heat on gravitating bodies, which is not due to air currents or to any other known form of force. A balance was made of a straw beam with pith ball masses at the ends, enclosed in a glass tube, and connected with a Sprengel pump. The tube being full of air, a spirit lamp was passed along the lower part of the tube: the pith ball descended slightly, and then rose to considerably above its original position. It seemed as if the true action of the heat was one of attraction, instantly overcome by ascending currents of air. A glass ball full of heated water was afterwards substituted for the lamp. The pump was then set to work, and the effect of the hot body regularly diminished until the gauge was about 12 millims. below the barometer, when it was scarcely noticeable; at 7 mill. it ceased entirely. The exhaustion was, however, continued; and it appeared that at 3 mill. the ascent of the pith, when a hot body was placed beneath it, was equal to what it had been in air of ordinary density. With the gauge and barometer level, the upward movement was not only sharper than in air, but took place under the influence of far less heat, the finger sending the ball up to its fullest extent. A piece of ice produced an exactly opposite effect to that of a hot body.

An incandescent spiral of platinum wire was then placed within the tube, and produced exactly the same effects. The rays of the sun and different parts of the solar spectrum acted so energetically as to endanger the apparatus. Various substances were used as gravitating masses—ivory, brass, platinum, gilt pith, silver, bismuth, selenium, copper, mica, charcoal, and glass, among others. The apparatus was somewhat modified by suspending the index from a cocoon fibre in a long tube furnished with a bulb at the lower end, and the results were still identical. After comparing these with Cavendish's celebrated experiments, the paper ends with a purely tentative discussion of their cause, in which no particular form of radiation appears to be suggested. The next contribution to the subject is a paper by Professor Osborne Reynolds, received by the Royal Society on May 16, 1874, and read the following month, headed "On the Forces caused by Evaporation from and Condensation at a Surface." He proceeds to show that the movements described by Mr. Crookes are due to the cause named in the title, and that they are valuable evidence of the truth of the Kineti

theory of gases, namely, that gases consist of separate molecules moving at great velocities. His apparatus was a light stem of glass, with pith balls on its ends, suspended by a silk thread in a glass flask, so that the balls were nearly at the same level. Some water was then put into the flask, and boiled until all the air was driven out of the flask, which was then corked and allowed to cool. When cold there was a partial vacuum in it, the gauge showing $\frac{1}{2}$ to $\frac{3}{4}$ inch pressure. It was now found that when the flame of a lamp was brought near to the flask, the pith ball which was nearest to the flame was driven away, and that with a piece of ice it was attracted. The pith balls were more sensitive to heat and cold when the flask was cold and the tension low, but the effect was perceptible until the gauge showed an inch, and even after that the ice would attract the ball.

The reason why the repulsion from heat was not apparent at greater tensions was clearly due to convection currents which the heat generated within the flask.

The condition of the pith also perceptibly affected the sensitiveness of the balls. When a piece of ice was placed against the side of the glass, the nearest of the pith balls would be drawn towards it, and eventually stop opposite it. If it remained there for some time, the vapour would condense on the ball near the ice, while the other ball would become dry, as was shown by the former becoming heavier. When the ice was removed, the dry ball was found insensible to the heat, or nearly so, while that which had been opposite the ice was more than ordinarily sensitive.

If the flask were dry, and the tension of the vapour reduced with the pump until the gauge showed $\frac{3}{8}$ inch, then the vapour, though purely steam, was not in a saturated condition, and the pith balls, which were dry, were no longer sensitive to the lamp, though they would still approach the ice. The last two facts seemed to show that a certain amount of moisture on the balls was necessary to render them sensitive to heat. With a dry flask and an air vacuum neither the lamp nor the ice produced their effects, even when the gauge was as low as $\frac{1}{4}$ inch.

It was argued from these data that the real force in action was due to evaporation and condensation, a view which was reduced to greater accuracy by means of mathematical formulæ. The condensible vapour in Mr. Crookes's experiments was held to be that of mercury; and the necessity for a higher degree of exhaustion to be due to the fact that a larger proportion of air, a non-condensible gas, was mixed with the vapour, which also was not in a state of saturation.

Professor Reynolds's paper presents, in addition, a very remarkable appendix. "Since writing the above," he says, "it

has occurred to me that, *according to the Kinetic theory, a somewhat similar effect to that of evaporation must result whenever heat is communicated from a hot surface to gas.*"

The particles which impinge on the surface will rebound with a greater velocity than that with which they approached, and consequently the effect of the blow must be greater than it would have been had the surface been of the same temperature as the gas. And in the same way, whenever heat is communicated from a gas to a surface, the force on the surface will be less than it otherwise would be, for the particles will rebound at a less velocity than that at which they approach.

Of this important generalization of the view with which the paper started, mathematical demonstration is given. Convection currents are said not to have much to do with Mr. Crookes's experiments, as one can hardly conceive that much heat could be communicated to the gas or vapour in such a perfect vacuum as that he obtained, unless indeed the rate of diffusion varies inversely as the density of a gas. To this a note is added which appears to go even deeper to the root of the matter than the text. "Professor Maxwell," it says, "has shown that the diffusion both of heat and of the gas varies inversely as the density; therefore, excepting for convection currents, the amount of heat communicated from a surface to a gas would be independent of the density, and hence the force (F) (previously given as the force arising from evaporation) would be independent of the density; that is to say, this force would remain constant as the vacuum improved, while the convection currents and counteracting forces would gradually diminish."

It will be seen that this valuable paper, which has been abstracted in considerable detail, ends by suggesting a far more general solution of the problem than that which is implied by its title.

In November of this year occur the remarks of the President of the Royal Society already cited.

What may be termed the second stage in the history of radiometry commences with a paper of Mr. Crookes's, received by the Royal Society on March 20, 1875, and read on April 22. It is marked by the same high level of experimental power, the same unwearied patience in varying experimental conditions, and by the same combination of scientific imaginative with accuracy of statement and mechanical aptitude as was the first.

It describes necessary improvements in the Sprengel pump and different forms of radiometric apparatus, by means of which the sensibility of the instrument is materially increased. The bulb is surrounded with adiathermanous media, and with a second vacuum. Measurement is substituted for mere demon-

stration of the occult force. The radiometric balance, shaped like an inverted T, is developed, and the similar behaviour of various gases at the minimum tension is established. The effect of interposing various screens, such as rock salt, rock crystal, smoky talc, plate glass, water, alum, calc spar, and ammonio-sulphate of copper of varying opacity, is tried. Experiments are made with the electric and solar spectrum passed through a quartz train, showing the activity of the ultra-violet rays.

After some discussion of the neutral point between attraction and repulsion, various explanatory theories are adverted to. The air-current and electrical theories are considered to be abundantly disproved. Professor Reynolds's evaporation is included in this catalogue, from the impossibility of conceiving that sufficient gas or vapour was present, after repeated heating of the instrument to redness at the highest attainable exhaustion, to drive backwards a heavy piece of metal, or generally to produce the effects ascribed to it. The writer most explicitly guards himself against substituting for these any theory of his own.

A supplement, received on April 20, examines more closely radiation from black and white surfaces, the former being the most energetically repelled. Here, for the first time, occurs the familiar name radiometer, and the substitution of rotation for oscillation. Four radial arms carry discs of pith lamp-blacked on corresponding sides, mounted on a central pivot, and enclosed in a globular vacuum. They revolve under the influence of radiation with a rapidity proportional to the intensity of the incident rays. Several of these instruments were exhibited at the *soirée* of the Royal Society, and from this period may probably be dated the great public interest manifested in the phenomena. It is deserving of notice that in this paper occurs an allusion to the "limiting walls of the space" in which the rotation takes place, as though the possibility of the action being one of mutual reaction had already presented itself to the writer.

At the anniversary meeting of the Royal Society on November 30, 1875, the Royal medal was awarded to Mr. Crookes as already stated.

Some experiments on the methods of obtaining perfect vacua formed the subject of a paper read before the Royal Society of Edinburgh on July 12, 1875. A brief *résumé* is given in "Nature" of July 15, under the heading "Charcoal Vacua." It is there stated that the writers, Professors Tait and Dewar, had taken advantage of the power charcoal has of condensing gases. While the exhaustion by means of a mercury pump is going on, the charcoal is kept heated; when the exhaustion has been carried as far as possible, the vessel is sealed, and, as the

charcoal cools, it condenses the very small residue of gas there may be present. They test the vacuum by the passage of an electric spark.

Professor Dewar then noticed that the effects of light and heat had been tried by many experimenters, and that in the "Edinburgh New Philosophical Journal" for 1828 there is an account of experiments by Mark Watt on the subject, made with apparatus differing little in appearance from that used by Mr. Crookes. A general account of Mr. Crookes's results was given, and the statement was made that this observer considered the results "inexplicable."

A substance opaque to heat-rays was then interposed between the candle and the balance, a layer of water $\frac{1}{4}$ inch thick diminishing the deflection to $\frac{1}{8}$ of the original amount. A smoked piece of rock salt or a solution of iodine in bisulphide of carbon were then interposed, and the deflection was found to be only diminished by the obstruction due to the glass walls of the tank.

Two equal discs, one of rock salt the other of glass, were attached to the glass fibre. The rock salt was inactive to the beam, the glass was active. The reason was given that the former, being transparent to heat, was not heated, whereas the glass was. The back of the rock-salt disc was then coated with lamp-black. Still there would be attraction. The heat and light, passing through the rock salt, were absorbed by the lamp-black at the surface of contact. The lamp-black is heated, but is so bad a conductor that before the heat can be conducted through it, it is conducted through the rock salt, heating it, and causing repulsion. The next modification was to substitute clear and ordinary sulphur for the salt. Clear sulphur, when acted on by light, resumes the appearance of ordinary sulphur, with disengagement of heat. A beam being thrown on this, the effect was attraction, the back being heated, and repulsion, there being attraction on the other side.

When the action takes place at ordinary pressure, it is probably due to convection currents. The air in front of the disc is heated and ascends, leaving a vacuum, and hence the disc advances. To understand the action when the exhaustion is more perfect, the quantity of gas actually present must be considered. A vessel of a like capacity would hold a bubble $\frac{1}{100}$ inch in diameter at ordinary pressure. It has been shown that the average path of molecules between two collisions is about $\frac{1}{10000}$ millimetre. If the pressure be reduced to $\frac{1}{4000000}$ the mean path will be 400 millimetres, or about a foot and a half. When, therefore, the gas is rare, the particles may get a long way off before they meet others, and so the action becomes perceptible. It was shown that the total mechanical action on a

square centimetre of black surface, from the radiation of a magnesian lamp at a distance of 150 millimetres, did not exceed a continuous pressure of $\frac{1}{30}$ milligramme.

On January 5, 1876, a third communication was received by the Royal Society, and read on February 10. The influence of various coatings on radiating and absorbing power is herein discussed, and a quantitative instrument on the principle of Bohnenberger's electrometer is described, in which repulsion is balanced against the magnetic couple, a small magnet being attached to the pith, and a controlling magnet mounted adjustably on the outside.

This immediately gives the apparatus practical value as a photometer, by balancing a standard candle against the source of light to be tested. The same balance can be made between different colours.

Here, for the first time, we meet with the vernacular name of "light mill" applied to the machine, which, though probably imitated from the "mouse mill" of another distinguished physicist, undoubtedly had the fault of implying a theory, and certainly affords a good instance of Bacon's "Eidola Fori."

A fourth communication, read on the same day, details experiments on the spectrum admitted to a radiometric balance through a quartz window. The maximum effect is found to be in the ultra-red, the minimum in the ultra-violet.

Then comes the momentous question, "Is the effect due to heat or light?" It is noted that "there is no real difference between heat and light; all we can take account of is difference of wave length; and a ray of different refrangibility cannot be split up into two rays, one being heat and one light."

Sunlight filtered through alum, glass, and water, so as to cut off the whole of the dark-heat rays, produced a deflection of 105° in the torsion apparatus; whereas on interposing a solution of iodine in disulphide of carbon, the deflection sank to 2°, showing that the deflection previously obtained was almost entirely due to light. A number of other substances were also experimented on, so as to get comparisons of action.

Professors Tait and Dewar's experiments, published in "Nature" for July 15, 1875, are examined by a special apparatus, and with different results from those of the original observers, for whereas they state that rock salt is inactive to the light of a candle, and glass is active, the difference between them is found by several concordant observations to be only in the ratio 39 : 40.

An extremely delicate torsion balance is lastly described, by means of which the radiation from a candle is measured in decimals of a grain; at twelve inches off it is found to be 0·000444 of a grain, at six inches 0·001772, or close to the

theoretical amount for half the distance, *i.e.*, four times, which would be 0·001776.

An observation on the "weight of sunlight" is thus obtained. On a dull day in December it is found equal to 10·2 candles, six inches off. This is by calculation equivalent to 2·3 tons per square mile.

Leaving at this point, according to the chronological order adopted, communications to the Royal Society, an important paper is contributed to the "Philosophical Magazine" by Mr. G. Johnstone Stoney. It commences by reciting the measurements just given, with others contained in an article on "weighing" a beam of light, contributed by Mr. Crookes to the periodical "Engineering" of February 18, 1876. The pressure is computed as equal to the hundredth of a milligramme on the square centimetre. The object of Mr. Stoney's communication is "to show that an excess of pressure of about this amount will arise under the operation of known laws."

He begins by estimating the outstanding pressure in the chamber of the instrument as about $\frac{1}{10}$ millimetre of mercury, caused in part by atmospheric air, in part by vapours of mercury and hydrocarbons, with, perhaps, other substances. Upon the vane fall such radiations from the candle as can pass through glass, which are competent to heat the blackened disc but not the transparent glass. It is assumed that the disc is thus heated $\frac{1}{10}°$ Centig. more than the glass, and that it in turn warms a layer of air in contact with it. Such a layer, in ordinary air, would be thin, about one "fourth metre," or the thickness of a sheet of paper, for 20° Centig.; and for 0·1 half a "sixth metre," explained as being a quantity equal to the wave length of light of mean refrangibility, and $\frac{1}{15}$th the size of human blood globules. Now, in the vacuum chamber the density is assumed at $\frac{1}{10000}$ of an atmosphere, and the thickness of the heated layer in this attenuated medium is 10,000$\frac{4}{3}$ times greater, or more than a decimetre, thus able to reach to the walls of the globe. "Some of the additional momentum communicated to molecules of air by the heated disc, instead of expending itself in intra-aerial collisions, and thus increasing the general temperature and pressure of the air, makes its way across the intervening stratum to the opposite walls of glass, where it occasions an increased pressure against them, of which the result is directed perpendicularly from the disc. An excess of force, equal and opposite to that on the glass, acts against the front of the disc, and is sufficient to account for the phenomena Mr. Crookes has investigated. The molecules reach the disc with velocities corresponding to 15°, and are thrown off from it with velocities corresponding to 15°·1. The augmentation of pressure will be half what would arise if they had

reached, and left it at the higher temperature." The uncompensated excess of pressure is, therefore, 0·000,011,5 of a gramme per square centimetre; Mr. Crookes making it = 0·000,01. It is obvious that all needed to substantiate the truth of this explanation was experimental evidence of a reactive force on the case of the radiometer, corresponding to the action on the vanes. This was immediately supplied in a paper read before the Royal Society on March 23, 1876, by Mr. Arthur Schuster, of Owens College. "Whenever," he says, "we observe a force tending to drive a body in a certain direction, we are sure to find a force equal in amount acting in the opposite direction on the body from which the force emanates. If the force is directly due to radiation, the reaction will be on the radiating body; if, on the other hand, it is due to any interior action, such as the one suggested by Professor Reynolds, the reaction will be on the enclosure of the moving bodies."

This proposition was easy to test by experiment. A radiometer was suspended on the bifilar principle, by two cocoon fibres, from the top of a vessel which could be exhausted, and its slightest movement detected by an attached mirror. The light of an oxyhydrogen lamp was concentrated on the vanes, which then revolved about 200 times a minute. The light being cut off by a screen, the position of the case was read by means of the dot of light on a scale. The screen was then suddenly removed, and in every case a large deflection was observed; the vessel being deflected in the opposite direction to that in which the vanes turned. When the velocity of these had become constant, the vessel returned to its original position. On suddenly cutting off the light, the vessel was again deflected, but in the opposite direction to that on starting the experiment. These experiments are easily explained, on the assumption that the force acting on the vessel enclosing the vanes is exactly equal and opposite to that acting on them. While the velocity of the latter is increasing, a force acts in the opposite direction on the vessel. When the light is cut off, the reaction of resistance will act on the enclosure, and the enclosure will turn in the same direction as the vanes.

"By means of the reaction of the enclosure," concludes Mr. Schuster, "I have been able to calculate the strength of the force; and I have found that the pressure on a surface on which light of equal intensity to that used in my experiments falls, is equal to that produced by the weight of a film of water on a horizontal surface equal in thickness to the length of a wave of violet light."

A paper by Professor O. Reynolds was read on the same evening, commenting on Mr. Schuster's experiment, and somewhat intensifying Mr. Crookes's differences of view; describing

him as "entirely repudiating" Professor Reynolds's explanation of the phenomena. It will be seen from the preceding page that this is hardly a fair representation of the remarkably impersonal and unbiassed attitude which Mr. Crookes maintained throughout the discussion.

On the 30th of the same month Mr. Crookes again takes up the subject in a paper "On the Movement of the Glass Case of a Radiometer." He describes a large radiometer with ten arms, eight of brass and two formed of a long watchspring magnet. The directive power of the earth prevents rotation unless a candle be brought near; but if once started it continues to revolve with the light some distance off. It was floated in a vessel of water, and four candles were placed round it so as to set the arms in rotation. A mark was placed on the glass envelope to show the amount of this. It turned about once an hour with the vanes. On bringing a powerful magnet near the moving arms they stopped, and the envelope began to revolve in the opposite direction to the arms, about once in two minutes. When the candles were removed and a magnet used to rotate the vanes, the case rotated in the same direction about once in three minutes. These experiments showed that internal friction, whether of point and socket or of vanes against residual air, is considerable.

He concludes by specifically denying his antagonism to "some strongly urged explanations," saying that he has already stated that he wishes to keep free from theories.

The April number of the "Philosophical Magazine" contains a further explanation of Mr. Johnstone Stoney's views as to the radiometer, wherein he distinguishes two stages: (1) the brief period of adjustment which arises when the light first falls on the blackened face of the disc; and (2) the permanent state which supervenes when the period of adjustment is over. During the former stage, in a partially exhausted globe, a thin layer of air in contact with the disc has been warmed and rarefied; another of varying temperature and density is in contact with the glass. If the exhaustion be carried farther, these two layers will become thicker until there is not room between the disc and the glass for their full development. Then arises what he terms "Crookes's pressure." "A procession of swift molecules at once commences, which is ever starting from the front or warmed side of the disc (the heater of the little engine) and jostling its way to the opposite hemisphere of cool glass (the cooler of the heat-engine). Another procession is as constantly starting from the cool hemisphere of glass, and working its way both up to the disc and to the regions behind the disc. Any member of the slow procession that comes into contact with the front of the disc is, in rebounding, converted into a member of the swift

procession; and any member of the swift procession that comes into contact with the glass is converted into a member of the slow procession. The characteristic of each procession is retained over a considerable distance, although it is gradually effaced as the procession advances. If there is room between the disc and the glass for the entire gradient, that is, for the whole thickness of those layers which I have described, then that part of the slow procession which reaches the disc will not only have lost its sluggishness, but will have attained the full molecular speed of the beginning of the swift procession; and the swift procession, where it comes into contact with the envelope of glass, will have become as slow as the beginning of the slow procession. In such a case there will be no Crookes's pressure. If there is not room for the full gradient, each procession will retain a portion of what characterises it when it reaches its destination. It would require the whole gradient to produce such a defect of density as would entirely compensate for the greater average momentum imparted by each molecule that strikes the front, as compared with the momentum imparted by each molecule striking the back of the disc."

In a vertical disc Crookes's pressure will be accompanied by the forces occasioned by a convection current. This will influence the motion of the vanes in three ways—(1) It will bring a continuous supply of cold air to the front of the disc, which, being thrown off with augmented molecular motion, will cause a recoil of the disc in the same direction as Crookes's pressure. (2) The convection current will also occasion a defect of tension in front of the disc, by that law of fluids in motion according to which the tension decreases along a stream wherever the velocity increases. This will occasion a minimum of tension where the velocity of the convection current is greatest, *i.e.*, in front of the disc, and will thus give rise to a force opposed to Crookes's pressure. (3) Lastly, the convection current, after being turned downwards by the roof of the little chamber, is likely to become a draught blowing upon the back of the disc with a force also opposed to Crookes's pressure. The resultant of these three forces seems in all the experiments to have been opposed to Crookes's pressure. At any particular degree of exhaustion it is only the difference between this resultant and Crookes's pressure which becomes apparent. It is evident that there is a certain tension, depending in some degree upon the form of the instrument, in which the above excess will be at a maximum.

In the "Philosophical Magazine" for May is a "Theory of the Radiometer," by Professor Challis. He commences by stating that rays of light incident on opaque substances are partly reflected without undergoing transmutation, and are partly

intromitted. The latter part is transmuted into rays of the kind which, by their dynamical action, produce *heat of temperature* as distinct from *radiant heat*. This is what takes place on the bright side of each vane. On the blackened side none of the light is regularly reflected, and the whole is transmuted into heat of temperature. The increase of temperature is therefore greater on the black than on the bright surface. The incident light thus produces an abnormal state of the atoms at and near the surface of the vane, analogous to the state of the superficial atoms of a body electrified by friction. He considers that the forces may result from the dynamical action of ætherial undulations. There will be a decrement of ætherial density from the dark towards the bright surface, and the atoms, being immersed in this variation of density, will be urged as if the vane were pushed on the black surface.

Thinking, according to this theory, that the rotation of the vanes might be affected by the streams of a magnet in the neighbourhood, Professor Challis found on trial that such was the case, the rate of revolution being much reduced by the proximity of a magnet of considerable power.

On June 15, 1877, Mr. Crookes again appeared before the Royal Society with a communication upon the "Influence of the Residual Gas." He states that he has been assisted by Professor Stokes. He admits that the first and most obvious explanation was that the repulsive force was directly due to radiation. Further consideration, however, showed that the very best vacuum which could be produced might contain enough matter to offer considerable resistance to motion; indeed, an instrument had been exhibited in 1876 to demonstrate this fact, which had also been proved by Dr. Schuster's experiments.

An apparatus had recently been constructed to discriminate experimentally between the viscosity of residual gas, friction of the needle point, and the torsion of the suspending glass fibre. It had been shown by this means that Professor Clerk Maxwell's law of the independence of a gas's viscosity and its density was practically correct. By using this apparatus the following measurements had been made:—

1. The logarithmic decrement of arc of oscillation when under no influence of radiation.

2. The successive swings and final deflection when a candle shines on one end of the blackened bar.

3. The appearance of an induction-spark between platinum wires.

The first measures the viscosity, the second gives the force of the candle's radiation, the third enables an estimate of the progress of the vacuum to be made.

It appears that up to a level position of gauge and barometer the viscosity of dry air does not vary much. On farther exhaustion radiation becomes apparent, viscosity being unaltered. The latter then begins to diminish and the former to increase. At length, radiation approaches a maximum, but viscosity begins to diminish rather suddenly. When this last has sunk to one-fourth, radiation diminishes, reaching less than one-half of its maximum. The number of gaseous molecules present is then not practically infinite, and the path of each of them is no longer small as compared with the globe. This point of exhaustion is far beyond that which is impervious to an induction current.

The conclusions come to are—That the force is due only indirectly to radiation; that the viscosity of the residual air is almost as great as at the atmospheric pressure; that with other gases the results are similar in kind but different in degree; and, lastly, that the repulsion is due to thermometric heat acting between the surface of the moving body and the case of the instrument.

It may be best to notice at this stage some foreign contributions to the history of the radiometer. As early as September, 1875, a paper appeared in Poggendorf's "Annalen," by Dr. F. Neesen, which advocated the influence of currents rising from inequalities of temperature. He used a modified form of apparatus, by which he established the fact that deflection diminishes in proportion as vacuum is produced, and is at last supplanted by the opposite deflection. This he attributed to heat currents, and herein he was followed by M. Poggendorf himself in the subsequent November, who was of opinion that the motions would not take place in a perfect vacuum. The whole subject was, however, still in its infancy.

In 1877 an excellent memoir was contributed to the "Annales de Chimie et de Physique" by MM. Bertin and Garbe. The writers commence with a historical summary of experiments, adding to them an extremely ingenious modification of the instrument brought before the Académie des Sciences by Mons. Salet. The globe in this case contains two sets of vanes, one above the other, both of them fixed. Between them is a horizontal plate of mica turning on a point. Directly light strikes the apparatus, the mica disc begins to turn in the opposite direction from that which the vanes would assume if they were free to move. The plate of mica may be considered to represent a portion of the case which has become movable, and therefore rotates just as the whole envelope does in Mr. Schuster's experiments.

A still more complete experiment, due to Signor Righi, is quoted from the "Scienza Applicata," Vol. I., part 2, page 8, in

which, after repeating the flotation and suspensory contrivances, the radiometer is floated on water upside down, so that its vanes rest on the projecting piece intended to prevent their falling off the needle point. In this case they form one piece with the case itself. The strongest beam from the oxyhydrogen lamp then directed upon them fails to produce the slightest deviation.

Upon these data a mathematical investigation of the forces involved in the rotation is entered into, in which the comparative weights of the case and the vanes, previously ascertained, are considered with reference to the combined motion of the two. It was found, that with a radiometer suspended in air, the currents due to its heating by the ray of light interfered with the strict ratio of mobility. The instrument was therefore suspended under the receiver of an air-pump, and the pressure reduced to 3 millimetres of mercury. Experiments made under these conditions agreed well with one another. Tables of these are annexed. The ratio of the vanes' speed to that of the case was always a little too great, as if the latter had been slightly retarded by the torsion of the suspension and the residual air of the receiver.

A memoir by Professor Challis, contributed to the April number of the "Philosophical Magazine," upon the cup-shaped radiometer of Mr. Crookes, with both sides bright, can only be briefly named for lack of space. The author attributes the rotation to thermo-electric ætherial currents, and appears to deny the presence of residual gas as the cause of motion.

On November 16, 1876, Mr. Crookes brought another series of experiments before the Royal Society, stating that he had succeeded in experimenting at still higher exhaustions, and with different gases. By means of a McLeod gauge he had been able to measure the pressure at any desired stage. He had thus estimated repulsion and viscosity, plotting the observations in curves, showing the relation of the two to one another. These are given with the paper.

Some technical improvements, such as the use of phosphoric anhydride instead of monohydrated sulphuric acid for drying the gases enable the rarefaction to be pushed to a higher degree than before. In this way, and sometimes with the assistance of chemical absorption, it is not difficult to exhaust a radiometer to such a point that it will not move to a candle placed a few inches off; but it has not been possible to stop the movement of the beam in the torsion apparatus.

The improvements added by Mr. Gimingham to the mercury pump render it so easy to obtain high exhaustions, that in preparing radiometers he now exhausts to one or two millionths of an atmosphere, then uses a hot-air bath of 300° C. to drive off occluded gases, and then attenuated air is let in until the

greatest sensitiveness is obtained. Rotating instruments will not move to moonlight, but a sensitive torsion balance does so.

The writer adopts Mr. Johnstone Stoney's explanation as given above, which has been tested by rotating the same fly in two bulbs of different size. An ingenious instrument has been made with a large and small bulb containing a single fly which can be balanced in either of them, its vanes being distant $\frac{1}{4}$ inch from the walls of one and $\frac{1}{2}$ inch from those of the other. In the smaller bulb the fly rotates about 50 per cent. faster than in the large.

The chief novelty, however, in this paper is the influence of the shape of the surfaces on the rotation. If the aluminium plates latterly used as vanes were turned up at the corners so as to make the blackened surface concave, it was attracted instead of being repelled by a candle, though still repelled by dark heat. Sloping the plates of a lamp-blacked mica radiometer, so as to have the black outside, and more facing the side of the bulb, greatly increases the sensitiveness.

Cup-shaped and conical discs materially modify the action and require more experimental investigation. A convex surface seems to cause greater pressure between itself and the bounding surface than one which is concave. Many illustrations of these facts are given in the paper, which want of space alone forbids our reproducing.

We thus arrive at the last in the long series of Mr. Crookes's papers, a series which his immense energy and unparalleled industry render it laborious even to chronicle. This was read on April 26, 1877, before the Royal Society. He therein describes a new form of instrument for which he suggests the title of Otheoscope (from ὠθέω, I propel).

In the radiometer, the surface which produces molecular disturbance is mounted on a fly, and is driven backwards by the excess of pressure between it and the sides of the containing vessel. As a heat-engine this arrangement is imperfect. The *heater* should be stationary, and the *cooler* movable. The driving surface should be of large size, and a good conductor of heat. The blackened surface acts as if a "molecular wind" were blowing from it, principally in a direction normal to the surface. This wind blows away whatever movable body happens to be in front of it, irrespective of colour, shape, or material; in its capability of deflection from one surface to another, its arrest by solid bodies, and its tangential action, it behaves in most respects like an actual wind.

The otheoscope, founded on these data, may be made similar to the radiometer, or in different forms. In the former case, at one side of the bulb is fastened a plate of mica blackened on one side, in a vertical plane. The vanes are of clear mica, and

in rotating pass the plate, leaving a space of about a millimetre. Light falling on the clear vane produces no motion, but if shining on the black surface the fly rotates as though a wind were issuing from this surface. In the latter case a large horizontal disc is made to revolve by the molecular disturbance on the surface of inclined metallic vanes, which are blackened on both sides so as to absorb the maximum amount of radiation; or inclined aluminium vanes are driven by molecular disturbance from a thick black mica disc below blowing through them. Both these last work on the smoke-jack principle. Six forms of otheoscope and thirteen new forms of radiometer are described in this paper; all, however, vary chiefly in mechanical arrangement, but not in the fundamental principle upon which they are based.

Here what may be termed the official history of the radiometer may be said to end for the present. But of course it has formed the subject of many popular lectures, and of articles in semi-scientific and literary periodicals. Of the former the most remarkable was a lecture given by Mr. Crookes himself at the Royal Institution; and in the latter class may be named memoirs in the journal "Engineering" and in the "Nineteenth Century." To the latter paper a contribution was also sent by Dr. Carpenter, in which, while commenting on Mr. Crookes's views with respect to spiritualism, he appeared to depreciate that gentleman's philosophical capacity on the ground that he had at first attributed the motion of the radiometer to the direct action of light. Professor Carey Foster commented on this article in his address as chairman of the Physical branch of the British Association. Dr. Carpenter replied by a letter in the columns of "Nature;" and hence arose a long and rather acrimonious controversy, in which all the gentlemen hitherto named, and some others, were for some months engaged. It will be seen from the narrative given above that the inventor certainly leaned at first to the Light hypothesis, which many experiments seemed to favour. But he certainly did not commit himself to it. Nor indeed, if he had done so, would it have been, as Dr. Carpenter seems to think, any evidence of logical imbecility and almost of mental obliquity. Oscillations of opinion around a new, startling, and unexplained fact are not strictly errors; but only provisional and perhaps feeble guesses, easily cleared away by a more forcible generalization. There is no doubt, for instance, that Faraday attributed the rotation of the plane of polarized light under the influence of an electro-magnet to some action of magnetism on light itself, and not, as has since been shown to be the case, on the molecular arrangement of the particles of heavy glass through which the beam was made to pass. But it never occurred to anyone to suggest that he in any way sank from his

high intellectual standard by the supposition; still less to connect the undoubtedly false hypothesis with his peculiar theological tenets.

Very little that was new came out of the long correspondence named above. The topic, already well threshed out, was threshed over again; the only grain of novelty being a difference between Professor Reynolds and Mr. Storey as to the exact proportion in which molecular motion and convection currents conduce to the ultimate result.

Perhaps one remark may be justifiable on the subject of spiritualism, so quaintly superinduced on matter apparently irrelevant; namely, that the candid and impartial tone throughout maintained by the discoverer of the radiometer leads to the belief that his apparent support of spiritualism is not so much credence, or an 'act of faith,' as a characteristic determination to examine any *supposed* fact, or series of asserted phenomena, with the widest liberality and the utmost willingness to be taught. To some minds it seems an anterior axiom that discrepant or unexplained observations should be tested by the method of strict investigation. Dr. Carpenter, on the other hand, refers to the general common sense of mankind, and of scientific men in particular, as having put spiritualism out of the pale of belief. It has, like an Athenian of old, been ostracized by popular disapproval. It is not to be denied, however, that the determination to explore, even in the face of *à priori* improbability, is more characteristic of the scientific temper; and to attempt to coerce such exploration by appeals to the *consensus omnium bonorum* may perhaps be learnedly named an act of scientific hyper-Grundyism.

W. H. Stone.

REVIEWS.

THE SWISS LAKE-DWELLINGS.*

THE history of the past teaches us whence our progenitors came, how their arts and customs originated, and how our lines of thought and action were at first marked out feebly by an incipient civilization, and have been more deeply channelled, for the diffusion of moral integrity, good policy, and personal comfort, in later ages. Without the experiences of history no nation can be well governed; without some knowledge of the past no man can be an eminent citizen of the state; without a respect for the material evidence of the lives and doings of foregone generations no man, no community, is at one with all the proper feelings and duties of humanity.

Where research among ancient parchments, papyri, coins, and other definitely inscribed monuments ceases to aid us in deciphering the past, we well know that the tombs and buried homes of still earlier, but unlettered races, yield in many places abundant material for the historian. The antiquary searches and sifts such relics for evidences of the pre-historic peoples, their race-characters, their utensils and weapons, their associated animals, wild or tame, their usual habits of thought and occupation, and sometimes he can even form a notion of their objects and modes of worship.

We lately noticed a most valuable repertory of facts† illustrating the customs and surroundings of some ancient tribes on British ground. We have now to draw attention to an enlarged edition of Dr. Keller's descriptions of the ancient Lake-dwellings of Switzerland and elsewhere. Of various ages, probably during a very long period of time, these timber structures in shallow water, near to, but separated from the shore, were habitually made in many parts of Europe, including the British Isles; and such are still constructed in South America, Central Africa, Japan, and elsewhere. Defence from enemies and wild beasts was probably the chief motive for this kind of dwelling. When burnt by invaders, or deserted under other circumstances, the relics of the piles and floors, of pottery, of tools and ornaments, of stone and metal, and of charred wood, cordage, cereals, &c., are found on the sites, and made to tell the tale of the past, so far as antiquary and naturalist can interpret their meaning, uses, and associations.

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* "The Lake-dwellings of Switzerland and other parts of Europe." By Dr. Ferdinand Keller, &c. Translated by J. E. Lee, F.S.A., &c. Second Edition, greatly enlarged. 2 vols. 8vo. pp. 725, Plates 206. London: Longmans & Co. 1878.

† Canon Greenwell's "Ancient British Barrows." See above, page 73.

Dr. Keller, the original observer and recorder of these discoveries in the Swiss Lakes, has not ceased from his well-directed labours, and, with his fellow-workers at Zürich and elsewhere, has amassed further stores of knowledge about the old Lake-dwellers. Mr. J. E. Lee has continued to gather and incorporate in his very useful translation of his learned friend's book the most important results of these well-sustained explorations. The new matter, occupying more than 260 pages, and illustrated by 109 new plates, gives Dr. Keller's Seventh Report, with new or enlarged accounts of Moringen, Lüscherz, Schaffis, Vingelz, Auvernier, Cudrefin, Heimenlachen, Constance, and Schussenried, and of the lakes Bienne, Geneva, Baldegg, Mond, Atter, Hallstatt, Neusiedler, and Paladru; besides places in Northern Italy and elsewhere, together with accounts of several special researches on bones, stones, canoes, &c.

Further notes on the Irish Crannoges, by Mr. Kinahan, and the Rev. E. Dumbleton's notice of a Welsh Crannoge, are added. The Irish Bog Cabin, described by Mudge in "Archæologia," vol. xxvi., and noticed by Lyell in his "Antiquity of Man," appears to belong to the same category of structures, and might have been mentioned.

Besides the English pile-structures at London, described by General Lane Fox, Mr. Lee might have added the discovery of such piles in the Norfolk Meres, due to Sir C. Bunbury, and recognized by Mr. W. M. Wylie in "Archæologia," vol. xxxviii., 1859, p. 11 (of the Memoir); and we may add that indications of pile-dwellings in Berkshire were described by a F.S.A., since deceased, before the Wiltshire Archæological Society at Hungerford in 1869.

Almost at the time of the publication of this compendious new edition, further ground was exposed at Estavayer and elsewhere on the Lake of Neuchâtel by works of drainage made in 1877. Unfortunately, though the Cantonal Government reserves the monopoly of search for antiquities, these are continually poached and carried off, without systematic observation as to their position and character.

We must congratulate the veteran antiquary of Zürich on the continuation of his praiseworthy labours, and on the extension of their results among us in this rich, well edited, and excellent translation by Mr. J. E. Lee. The scientific researches have been carried on voluntarily and assiduously for the benefit of the community; and the translation and its enlarged edition have been evidently a labour of love, and a cordial friendly tribute to the master's worth.

DEVONIAN AND CARBONIFEROUS FOSSILS.*

NEARLY ten years ago Dr. Bigsby issued a "Thesaurus Siluricus,' or tabular list of described Silurian fossils from all parts of the world, furnishing in a very condensed form an immense amount of useful information upon their distribution in space and time. Since the publication of the above work its venerable author has been almost constantly engaged in the

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* "Thesaurus Devonico-Carb niferus. The Fauna and Flora of the Devonian and Carboniferous periods. The Genera and Species arranged in tabular form, showing their Horizons, Recurrences, Localities, and other facts." By John J. Bigsby, M.D., F.R.S., F.G.S. 4to. London: Van Voorst, 1878.

preparation of a similar book upon the fossils of the Devonian and Carboniferous periods, which has at length appeared under the title of "Thesaurus Devonico-Carboniferus.'

The general plan that he has followed is the same in this as in his former work, but there is a little difference in the treatment of its two sections. In treating of the Carboniferous series, its wide distribution and great importance have led the author to separate the registers of species from North America and the European area, and to indicate the countries and states in which they occur in a series of columns, whilst by placing the American and European lists on opposite pages he is enabled to present the whole information with respect to each genus and species at one view, and at the same time to furnish a means of contrasting the fauna and flora of the two richest and best worked regions. The Carboniferous fossils from localities outside the areas above indicated are catalogued separately in special lists. In the case of the Devonian the smaller extent of the subjects permits all the information to be brought together in one table, and the author has not considered it necessary to separate the North American fossils from the rest. Some notion of the labour the author must have undergone in the preparation of these elaborate tables may be formed from the fact that he enumerates in them, with the particulars above indicated, over 14,000 species of fossils.

The book, however, contains more than this, and vindicates its title to be called a "Thesaurus" by other claims. We find in it, besides discussions of nearly all points of interest that can arise from the consideration of such a series of palæontological tables, bibliographical lists of value, and notes on the recognised horisons and subdivisions of the Devonian and Carboniferous formations in various countries, often giving the views of different authors and always indicating the source of the information, so as to enable the student wishing for further information to go at once to head-quarters.

If, as Solomon tells us, "of making many books there is no end, and much study is a weariness of the flesh" (and there are few naturalists of the present day who will not subscribe at all events to the former proposition), students of the Palæozoic rocks can hardly fail to feel under great obligations to Dr. Bigsby, for having taken so much of the "weariness" upon his own shoulders. Although we have no doubt that imperfections might be indicated in his present work,* and its full utility can only be realized by careful study of its contents, the enormous amount of information brought together in it renders it a perfect mine of knowledge to the palæontologist and geologist.

ANTHROPOLOGY.†

OF all the departments into which the great science of Biology is divided, Anthropology, if we are to judge from many of the works published upon it, is the one which calls for the widest range of knowledge on the part of its votaries. From some indications, especially German ones, the

* We may notice that at p. 26 the Merostomata are represented as equivalent to Articulata, instead of as a subclass of Crustacea; and that at p. 125 the Fichtelgebirge are inserted as if they belonged to Spain.

† "Anthropology." By Dr. Paul Topinard. With preface by Professor Paul Broca. Translated by R. T. H. Bartley, M.D. 8vo. London: Chapman and Hall. 1878.

proper motto for a treatise on Anthropology would be that prefixed by Southey to his well-known book, "The Doctor,"—*De omnibus rebus et quibusdam aliis*,—for it would appear that the complete anthropologist has not only to study all the morphological and physiological phenomena presented by man and other animals, the relations of man to the universe, his mental, moral, and social qualities as observed in the different varieties of mankind, in fact all the observable phenomena which may fairly claim the attention of a naturalist, but he must also possess a considerable acquaintance with metaphysics, which last is a hard condition to impose upon any one.

M. Topinard in his treatise on Anthropology, a translation of which is just published by Messrs. Chapman and Hall in the "Library of Contemporary Science," does not make quite such heavy demands on the intellectual powers of his readers. His book furnishes an excellent summary of the present state of Anthropology (of course according to the author's personal views in all disputed points); and the full description of the methods of research adopted and the kind of investigation on which anthropological results are founded, will render it an admirable guide for the student in consulting special works on the subject, and a most useful handbook for travellers in distant lands.

At the close of a short introductory chapter, in which the author defines his science and sketches out the general plan of his work, he treats of the classification of the Mammalia, and indicates the two points of view from which the position of man in the system have been regarded by different zoologists—namely, that according to which he is to take rank as a distinct order of Mammalia, and that which shows him as merely the highest type of an order (Primates), including also the apes, monkeys, and lemurs. "The question," as the author says, "resolves itself into the following terms:—What is the value of the characteristic points of difference between man and monkeys, and especially the anthropoid apes? Are these differences as great as those which separate two families or two orders?"

The succeeding section of the work (Part I.) is devoted to the consideration of this question, for the elucidation of which the author describes the structure of the human body, and especially of its more characteristic parts, at considerable length, and compares its characters and some functional and other peculiarities with those presented by the animals universally admitted to approach man most nearly in the zoological scale. The conclusion at which he arrives is that man is anatomically more nearly related to the anthropoid apes than these are to the old world monkeys, which stand immediately below them, and which again are, he thinks, more nearly allied to the American monkeys (Cebidæ) than to the anthropoid apes. Hence "the separation to be made at the extreme of the series, between the inferior monkeys and man, can only* be logically placed between the anthropoid and the so-called common monkeys. This leads us to Mr. Huxley's classification: (1) Man and the anthropoid apes; (2) the monkeys of the old and new continents; (3) lemurs." But M. Topinard is not satisfied with Professor Huxley's arrangement, as he considers that "we must necessarily draw a strong line

* Here the translator seems to have fallen into error; he says "cannot be logically placed," which is opposed to the whole argument.

of demarcation between man and the anthropoids," the chief reason for this being apparently the development of the brain in the former; the old and new world monkeys have an equal claim to separation, and this leads to the adoption of M. Broca's arrangement of the order Primates under five families, the first of which is formed by man.

M. Topinard next attacks a very difficult subject, namely, the specific unity or multiplicity of mankind. The greater portion of this section of his book is occupied by an excellent discussion of the physical and other characteristics of the races of man and a description of the methods of investigation employed by various *savants*. In his classification of races, which follows, he to a great extent discards the divisions into three or five great families which have so generally been adopted, regarding it as better in the present state of science to define a series of distinct types, and indicate their general relationships, leaving it to the future to group them, if it be possible, under larger categories. The difficulty of deciding whether these types are distinct species, equivalent to those recognized by zoologists in other groups, arises, according to the author, "from the confusion created by intermediate types, some due to crossing, others natural, and in a state of transition, such as we meet with in every degree in the animal series:" but if we take "simple general types, as the white, the yellow, and the black with woolly hair; or particular ones, such as the Scandinavian, the Semite, the Esquimaux, the Mongol, the Kaffir, the Bosjesman, the Negrito," the differences separating them are as great as those between species of the same genus of Mammals. From this and other arguments the author concludes that "The HUMAN FAMILY, the first of the ORDER of Primates, is composed of SPECIES, or fundamental human races." We cannot help regarding this polygenistic argument as the weakest part of M. Topinard's book. In discussing such a question we have no right to leave out of consideration at all events the "natural intermediate types, in a state of transition" above referred to; and further, in the light of the transformist theory which M. Topinard seems inclined to adopt, we cannot realize the idea of "fundamental human races" possessing "primordial characters." The last chapter of the book is devoted to a consideration of the origin and genealogy of man, in which, as already hinted, the author adopts the prevalent transformist views.

In conclusion we may compliment Dr. Bartley on the manner in which he has performed his task. His translation reads admirably, and we have no doubt is on the whole very correct, but we have detected two or three places where he is evidently in error, although we have not the French original to refer to. One of these has already been pointed out; another occurs at p. 532, when, in a sketch of Häckel's genealogy of man, the adaptation to terrestrial life is said to have "ceased" instead of "commenced" at the sixteenth stage. At p. 22 there is the following passage:—"The Didelphs, one of the most correctly defined of the sub-classes, from being based on their *habitat*, have been displaced and abolished, most of them being classed with the *Edentata* or the *Rodents*, the remainder becoming a distinct order under the name of *Pedimana*." This may not be a mistranslation, but it is certainly unintelligible to a zoologist. But the funniest error of all is at p. 199, where the French word "désormais" figures as the name of an author!

AMERICAN SURVEY PUBLICATIONS.

THE most important work published by the United States Survey of the Territories that has appeared during the present quarter is Professor Leo Lesquereux's description of the "Tertiary Flora" of the Western Territories." In this splendid volume, which is to be regarded as the complement to his previous great work on the "Cretaceous Flora" of the same region, Professor Lesquereux describes nearly 330 species of plants which have been obtained from the great series of lignitiferous deposits spread over a vast portion of Western North America, extending certainly from New Mexico in the south to and beyond the northern boundary of the States. The true position of these lignitic beds was long a matter of dispute, seeing that in their lowermost deposits certain fossil animals of Cretaceous type had been found. From the researches of the late Professor Meek "On the Invertebrate Cretaceous and Tertiary Fossils of the Upper Missouri Country" (see "Pop. Sci. Rev.," N.S. Vol. I., p. 79) it seems clear that in these lowest beds, immediately succeeding the series known as the Fox Hills group, the highest undoubtedly Cretaceous series, we have traces of a transition from Cretaceous to Tertiary conditions; but, considering the preponderance of the evidence from the fossil Flora, if a line is to be drawn between the two it must pass below the lignitic beds. It is in this sense, apparently, that Professor Lesquereux treats all the plants described in his present magnificent work as of Tertiary age.

It will be unnecessary here to refer in detail to the species described, most of which are new, although a few are identical with, and many related to European and Greenlandic forms. We may mention, however, that the author notices four species of parasitic Fungi (*Sphæria* and *Sclerotium*), and has also discovered traces of a Lichen which he refers to the genus *Opegrapha*. Four Lycopods are described, three of which belong to *Selaginella*; the Ferns belong to Tertiary types; and the total absence of *Gleichenia* is interesting in connection with the question of the age of the deposits. Among the Phænogams we find the usual Tertiary genera.

By his researches Professor Lesquereux has determined the equivalence of the different deposits over a wide extent of country, and has also been led to recognize four groups in the Lignitic formation of the Upper Missouri and Colorado regions.

The first or lowest group, from which, probably owing to its being most worked for fuel, 200 out of the 329 recorded species have been obtained, has only 16 species known to occur in higher Tertiary groups. Its flora includes nearly all the Ferns, Palms, Figs, Cinnamons, *Magnoliæ*, and Rhamneæ of the Lignitic formation. It is referred by the author to the Lower Eocene.

The second or Evanston group, from which only 34 species of plants are known, has 20 of these peculiar to itself. Its characteristic plants are five

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* "Report of United States Geological Survey of the Territories." F. V. Hayden, U.S. Geologist-in-Charge. Vol. VII. "Contributions to the Fossil Flora of the Western Territories." Part II. "The Tertiary Flora." By Leo Lesquereux. 4to. Washington: Government Printing Office. 1878.

Laurineæ and two *Araliæ;* the former possessing Miocene affinities; the latter having "the same degree of relation to Cretaceous types of Nebraska as to Pliocene species of California;" and its Miocene affinities are further witnessed by the presence of *Taxodium distichum miocenicum* and of *Populus arctica.* The species common to this and both the higher and lower groups are of Miocene type, but Professor Lesquereux says "This small Flora seems to represent a peculiar stage intermediate between the first and the third division," and further on he remarks that "according to Professor Cope's statement, bones of Eocene vertebrate animals have been found in connection with it," and seems inclined to regard it provisionally as Upper Eocene.

The third group, that of Carbon, is manifestly related to the Miocene both of Europe and Greenland, not only by the general facies of its plants, but also by the presence of numerous species such as *Platanus aceroides* and *Guillelmæ, Populus arctica, Taxodium distichum,* and species of *Acer, Betula, Quercus,* and *Corylus.* Palms are entirely wanting, not even the doubtful fruits (*Palmocarpon*) which occur in the second group being found here. Its probable age is Middle Miocene.

In the fourth, or Green-River group, we have the same predominance of unmistakable Miocene forms, but many of its species display still more modern relationships, and the author regards it as Upper Miocene. Of course the whole of these geological divisions are to be regarded as provisional and approximate only; they are, as the author says, "like the first outlines traced for the preparation of a map: they may be erased or modified; the spaces have to be filled as our acquaintance with the Tertiary becomes more intimate." The sequence of events indicated, as Professor Lesquereux thinks, by the result of his researches, as also his opinion upon the position in the geological series of Lignitic beds, as a whole, may be gathered from the following extract. He says, "I readily admit the facts, established from sufficient evidence, that a fossil Cretaceous fauna has left traces of its presence up to the very base of the Lower Lignitic measures, and that there the remains of a few invertebrate animals and those of one Saurian, all of Cretaceous types, have been found in connection with plants whose characters have been considered until now in Europe as representing a Tertiary Flora. Is the flora to decide the relation of age of the formation, or the Saurian bones of Black Buttes, with the few shells of brackish water, either found there, or which may be found hereafter in the same circumstances? The slow upheaval of a new land at and from the base of the Lignitic is sufficiently evidenced. . . . This land, which, rising up, is cut, of course, by shallow brackish swamps or estuaries, is the beginning of a whole formation of wide surface and great thickness, where the plants, preserving their Tertiary characters, have constituted the materials for the composition of the numerous coal strata, which constitute an essential part of it. In those brackish estuaries paleontologists have already recognized species of positive Tertiary relation, mixed with a few remains of Cretaceous types. But these low swamps drying up, their Cretaceous fauna is gradually reduced in its representatives by the influence of different atmospheric circumstances, while that of younger types becomes predominant. Henceforth the Cretaceous animals appropriate to deeper water may live still; their remains may even be found hereafter

mixed with Tertiary strata, but their presence cannot modify the age of the new land formations. This admission would be against reason quite as much as the assertion that we are now still living in Cretaceous times, because animals of Cretaceous type are dredged from the depths of the ocean."

With this extract we may conclude our notice of Professor Lesquereux's work, the value of which is enormously enhanced by the beautiful plates which illustrate it. These are 64 in number, and contain excellent figures of every species referred to in the text—a condition, indeed, which is absolutely essential to every descriptive book on fossil botany.

Next to Professor Lesquereux's Tertiary flora, the most important contribution that we have received from the Survey is the first part of the fourth volume of its Bulletin,* which contains no fewer than 14 articles, most of them of considerable interest. The majority are of zoological nature. Thus we have an interesting account of the birds of the Lower Rio Grande of Texas by Mr. G. B. Sennett, edited by Dr. Elliot Coues, devoted especially to a description of the habits and manners of the birds observed by the author, but including also many valuable notes on their characters by the editor. A new species of Tit is described under the name of *Parula nigrilora*, Coues. Another important ornithological paper is that by Mr. Ridgway on the American Herodiones, of which the first part here appears, containing a synopsis of the American genera of Ardeidæ and Ciconiidæ, with a monograph of the American species of the genus *Ardea*. The American forms of the group Herodiones are referred by the author to five families, the Cancromidæ (Boatbills), Ardeidæ (true Herons), Ciconiidæ (Storks), Ibididæ (Ibises), and Plataleidæ (Spoonbills). The Eurypygidæ or Sun-Bitterns, which are also an American group, are placed by some authors near the Rails, but Mr. Ridgway seems to think that they may nevertheless be Herodiones, although he does not include them in his synopsis. The monograph of the species of *Ardea* contains descriptions of four species, three exclusively American, and the fourth our Common Heron, which is said to occur occasionally in Greenland. Two new genera of herons (*Dichromanassa* and *Syrigma*) are proposed. The two American Storks, according to Mr. Ridgway, present a rather difficult question of synonymy, which we may recommend to the attention of our ornithological readers; for one of them the author has established the new genus *Euxenura*, characterized especially by peculiarities of the tail, and the remarkable development of the lower tail-coverts.

From birds we may pass to Mammals, under which head we have a series of notes, by Dr. McChesney, on the animals of that class observed by him at Fort Sisseten in Dakota, of which those relating to the Rodents are the most important. Dr. McChesney bears testimony to the recent disappearance of the larger Mammals under the pressure of advancing civilization. The most interesting communications on Mammalia, however, are two notes by Dr. Coues, on consolidation of the hoofs in the Virginian deer, and on a

* "Bulletin of the United States Geological and Geographical Survey of the Territories." Vol. IV., No. 1. 8vo. Washington: Government Printing Office. 1878.

breed of solid-hoofed pigs, apparently established in Texas. To these papers we shall refer in our "Summary."

The reptiles of Dakota and Montana furnish the subject of an article by Dr. Coues and Dr. H. C. Yarrow, which includes descriptions of a series of species such as makes our British Reptile Fauna appear very insignificant, although, as it includes two rattlesnakes, the colonists of these western Territories are perhaps not much to be envied for this pre-eminence.

The remainder of the zoological articles relate chiefly to insects and, indeed, to the single order Lepidoptera. Mr. Chambers describes a considerable number of new species of Tineina, chiefly from Texas, although a few from more northern localities are interspersed; and follows up this paper with a classified catalogue of the plants on which these small moths are known to feed in the United States and Canada, and this again with an index to the described Tineina of the same countries. This last will prove a most valuable aid to entomologists. Mr. Grote describes numerous new species of Noctuid Moths, chiefly from California, and furnishes notes on some other species; and Mr. Scudder has a short notice of the Butterflies collected by Dr. Edward Palmer, in the arid regions of southern Utah and northern Arizona, during the summer of 1877, which also includes descriptions of new forms.

Carcinologists will be interested in an article by Mr. J. S. Kingley on the North American species of the genus *Alpheus*, to the number of which the author adds considerably, perhaps too liberally, considering the amount of materials at his command. *Alpheus minus* and *heterochelis* of Say, and four of the author's new species, occur on both sides of the Isthmus of Panama, and the author gives a list of all the species of Decapod Crustacea that he knows of as being reported from both coasts. There are 26 in all.

The remaining articles relate to palæontological matters. In one of them Professor Cope describes some fossil fishes from the Cretaceous and Tertiary deposits west of the Mississippi; in the other he takes up the cudgels in defence of his order Pythonomorpha, and in opposition to the views expressed by Professor Owen as to the affinities of the Mosasauroid reptiles on which that order was established.

Dr. Hayden's Preliminary Report on the Field Work of the Survey under his direction in the season of 1877* is a record of persevering activity which promises most important and interesting results. Considerable progress was made in the survey of parts of Wyoming, Idaho, and Utah, and various geographical and geological details are here briefly indicated, the principal report being that of Mr. O. St. John on the geology of the Teton district, which appears to display very interesting but rather complex characters. Dr. C. A. White, the palæontologist to the survey, has made some extensive journeys in various directions for the purpose of investigating on the spot the palæontological characters of various formations in districts which have been surveyed, or are now in course of surveying. Besides demonstrating the identity "of the lignitic series of strata east of the Rocky Mountains in Colorado, with the Fort Union group of the Upper Missouri River, and also

* "Preliminary Report of the Field Work of the U.S. Geological and Geographical Survey of the Territories for the season of 1877." 8vo. Washington: Government Printing Office. 1877.

with the great Laramie group of the Green River Basin and other portions of the region west of the Rocky Mountains," he found "the planes of demarkation between any of the Mesozoic and Cenozoic groups, from the Dakota to the Bridger inclusive, to be either very obscure or indefinable; showing that whatever catastrophal or secular changes took place elsewhere during all that time, sedimentation was probably continuous in what is now that part of the continent from the earliest to the latest of the epochs just named," a conclusion perfectly in accordance with that indicated in connexion with Professor Lesquereux's work. We have a notice here of the discovery, by Messrs. Scudder and Bowditch, of very rich deposits of fossil insects in the Tertiary Basin of Florissant, Colorado, where Mr. Scudder estimates that the insect-bearing shales, "have an extent at least fifty times as great as those of the famous locality at Œningen." Many thousand specimens of insects and plants have now been received from Florissant, and others are being sent in from another new locality in Wyoming; the whole will form the materials for a most interesting volume of the Records of the Survey. Professor Leidy's investigations of the Rhizopods, and the researches of Sir Joseph Hooker and Professor Asa Gray on the botany of the region, are briefly referred to; as also the investigations that have been made by officers of the Survey of the singular cliff dwellings and towns of the ancient inhabitants of New Mexico and Arizona, models of the more interesting of which are being prepared on a considerable scale.

We do not know whether we should be right in crediting the Survey with the production of a "Palæontological Bulletin,"* two numbers of which we have received from Professor Cope. They contain descriptions of vertebrate fossils chiefly from Secondary and Tertiary deposits of the western Territories, and are evidently advance-copies of communications to the American Philosophical Society, issued for the purpose of securing priority. With this view one number is said to be "Published December 10, 1877," and the other to be "Printed January 12, 1878." It is melancholy to see the struggle for priority prompting good men to such futile devices; these books are *not* published, for the very essence of publication consists in the thing published being procurable by any student who may hear of its existence. If our American friends will persist in racing each other with their descriptions, why don't they adopt the simple method of making the issue of their pamphlets a real publication, by simply having a bookseller's name and address on the title page? If they wish to limit the circulation of their productions they can easily do so by placing a high price upon them, as Her Majesty's Geological Survey has lately done with distinguished success.† The two numbers before us of Professor Cope's "Bulletin" contain papers on New Vertebrates from

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* "Palæontological Bulletin," Nos. 27, 28. 8vo.

† In saying this we do not wish to reflect upon the officers of the Geological Survey, knowing well that the absurd prices which have been put upon the recent publications of that most valuable institution have been adopted at the dictation of an office under whose thumb the insane method of managing such matters in England has in this respect placed the control of the Survey's action. It is quite natural that a Stationery Office should contain a plentiful supply of red tape, but it is rather hard that its clerks should be allowed to employ that commodity in choking one of our few scientific departments.

the Upper Tertiaries of the West (Mammals, Chelonians, and Fishes), on New Saurians from the Trias of Pennsylvania, and on the Vertebrata of the Dakota epoch of Colorado. In the first the most interesting species noticed are *Pithecistes brevifacies*, a monkey? and *Tetralophodon campestre*, the latter the second North American species of its genus. The Triassic Saurians include new species of *Thecondotosaurus* and *Palæosaurus* and *Suchoprion aulacodus*, Cope; and the third paper contains descriptions of *Camarasaurus supremus*, *Amphicœlius altus* and *latus* (the latter two reprinted from No. 27!), *Symphyrophus musculosus* and *Caulodon leptoganus*, with notices of some other species.

WHITE'S SELBORNE.*

WHAT is the source of the perennial charm that seems to invest Gilbert White's "Natural History of Selborne?" a book which can probably count more editions, or rather reprints, than any other original work, not purely of literary interest, except perhaps Walton's "Complete Angler." It is evidently not solely for the sake of the natural history observations contained in it that this book has been the delight of old and young ever since its appearance; for, valuable as White's observations are, the student may get most of them in a more systematic form, and combined with those of other naturalists in the various books upon special departments of British zoology, which have appeared of late years. We must seek elsewhere for the cause of the continued popularity of the "Natural History of Selborne," which it seems to us is to be found rather in the mode in which the various subjects treated of are presented to the reader, than in the intrinsic value, great as this may be, of the materials of which it is composed.

In fact, as in the case of Walton's "Angler," already referred to, although not to the same extent, it is the workmanship that gives much of its value to the author's production. Thousands have read Izaak Walton's book who never intended to wet a line; and in like manner, thousands have read the "Natural History of Selborne" without feeling any particular interest in its natural history, or desire to be converted into naturalists by its perusal. The source of the popularity of the book is to be found in the charming manner in which the author has given the results of his observations on the objects surrounding him, and in the genial humour which breaks out from time to time and illuminates his pages.

In thus maintaining that it is chiefly as a literary performance, as the work of a man of genius, that White's "Selborne" has retained its hold upon the British public, we would not be understood to speak slightingly of its merits as a natural-history book. On the contrary, so admirably careful was White in all his researches, so open was his mind to the reception of all opinions connected with his favourite studies, and so enthusiastic was he in their prosecution, that even in this respect his book may be held up as a

* "The Natural History and Antiquities of Selborne, in the county of Southampton." By the late Rev. Gilbert White, formerly Fellow of Oriel College, Oxford. Edited by Thomas Bell, F.R.S., F.L.S., F.G.S., &c., Professor of Zoology in King's College, London. 2 vols. 8vo. London: Van Voorst. 1877.

model for all field-naturalists, although we fear that few are capable of following in his footsteps. We have, indeed, dwelt so strongly on the literary charms of the book, on the genius which, by a series of letters beautiful in their seemingly unstudied simplicity, has rendered the name of an obscure Hampshire village a household word wherever the English language is read, because this great element of its popularity seems generally to have escaped the penetration of its numerous editors. Nearly all the leading popular zoological writers of the last fifty years have tried their hands upon an edition of White's "Selborne," and most of them have overlooked the characteristic of the work to which we have above alluded, and taken White's text simply as a peg on which to hang notes embodying all they knew or could scrape together upon any subjects mentioned by him. Hence most of the editions are overloaded with notes, which, whatever may be their intrinsic value, have certainly the inconvenience of too frequently diverting the reader's attention from the text.

In Mr. Bell's edition, just published, this is not the case. The venerable editor, who has resided for many years in White's own house at Selborne, has evidently appreciated justly the artistic merit of the book, and as he tells us in his preface his object in the notes appended to this edition "has not been to treat at large on the general history of the various objects referred to . . . . but, rather to render as correct and complete as lay in his power the text of Gilbert White, with such additions and modifications as have been observed in the district since the first publication of his work." Thus the notes, several of which are borrowed from previous editions, are almost entirely such as serve to supplement the text, to correct certain errors into which the author had fallen, and to elucidate points which he left doubtful, the particulars recorded being in most cases founded on local observations for which the editor's long residence on the spot has given him abundant opportunities, and serving literally to complete the "Natural History of Selborne."

White's original work, including both the "Natural History" and the "Antiquities of Selborne," furnished with notes as above described, and accompanied by the Naturalist's Calendar, Observations on Various Parts of Nature and other documents of White's annotated by Markwick, occupy the first volume of Mr. Bell's edition. Of this we need only say that we have in it a careful reprint of the original text, accompanied, as already stated, by very valuable notes selected solely as completing or emendating White's work. This the editor has prefaced with a short memoir of Gilbert White, in which, as might be expected from the even tenour of his life, the sensational element is entirely wanting. White lived for the greater part of his long life on the property which he had inherited from his father at Selborne, where he was contented with officiating as the curate of a non-resident vicar, refusing various offers of college-livings which would have drawn him away from the district in which he delighted, and which his labours have made familiar to the whole civilized world.

Mr. Bell's object, however, in preparing this edition, was to raise as fair a monument as possible to the memory of the illustrious naturalist of Selborne—to give the clearest possible picture of Gilbert White and Selborne. With this view he has printed in his second volume all the extant corre-

[illegible] Gilbert White. He was born at [illegible] in the parish [illegible] was educated [illegible] Many [illegible] from time to time [illegible] Natural History [illegible] many which [illegible] correspondence, chiefly [illegible] Linnæus, [illegible] Pennant, [illegible] with a little [illegible] Gilbert White [illegible] singular character of the [illegible] and is [illegible] and himself [illegible].

[illegible] White [illegible] may indicate a particular [illegible] Gilbert White, chiefly [illegible] Pennant, which [illegible] a singular [illegible] White, before the difficulties of [illegible] and even [illegible] unfortunately prevented [illegible] the correspondence between the two [illegible] Gilbert White and Linnæus, will be found most interesting [illegible] who have made a [illegible] the history of Zoology. We have [illegible] which [illegible] the mind [illegible] investigations which [illegible] engaged the attention of its predecessors. We [illegible] of the great Swedish naturalist represented as actually starving [illegible] during a journey [illegible] and it was so [illegible] that a [illegible] naturalist is said to have been excluded [illegible] learned Society because he had advocated the adoption of the [illegible] system in Britain and we have heard of an entomologist who lost [illegible] specimens which, it is said, were [illegible] Linnæus," and the [illegible] words and discussions of their partisans have a somewhat antiquated [illegible] about them to our modern ears.

The correspondence is followed by a letter "on the Sense of Hearing in Fishes," which was evidently intended to have formed part of the [illegible] the "Natural History," and this again by a sermon given [illegible] sample of White's mode of preaching, and, as the editor says, [illegible] ordinary character of the best village sermons of the period," a [illegible] simple discourse, directed chiefly to the improvement of the moral character [illegible] of the hearers.

After the sermon comes one of the most amusing items in this [illegible] namely a literal reprint of an account of expenses incurred by [illegible] White, for about two years, during part of which he held the [illegible] Proctor in the University of Oxford. Mr. Bell says of it that it has [illegible] struck him "as exhibiting in its simplicity that combination of [illegible] kindliness and generous hospitality with habitual prudence, punctiliousness, and methodical habits which was so characteristic of the writer in his after-life. As an indication of some phases of ordinary college [illegible] the time, it is not without some amusing interest." The first thing

trikes one on inspecting it is the peculiar filling up of all three money columns in every instance; thus White writes that he paid for—

"Two Sevil-oranges . . . . . 00 00 03;"

and on another occasion that he—

"Gave Jenny Croke a round China-turene,
"Being prevented paying for y^e^ post-chaise . . . 01 03 11"

Certain items will excite the envy of some people in the present day; for example we have one day—

"Oysters . . . . . 00 00 02;"

and another—

"Oysters . . . . . 00 00 03*d*."

Lovers of oysters would be puzzled to get any appreciable quantity of their favourite mollusc for such sums nowadays. Life in Oxford was probably very jolly in White's time, and he seems to have gone in pretty freely for the festivities of the place, the numerous tips to "Mrs. Croke's Man," "Dr. Bristow's Man," &c., being, no doubt, so many records of good dinners or other entertainments. A frequent item in the account is "Lost at Cards," but the amounts show that the gambling was not carried to a ruinous extent, eighteenpence being, we think, the extreme amount of White's losses on any one occasion. On one day we find, "Lost at Goose, 00 00 06*d*.," but this seems to have been at Selborne, probably in a family party. A curious item occurs on April 20, 1752, namely:—

"Present to the Vice-Chan. a Loaf of Double
Refined Sugar 7lbs. at 13*d*. . . . 00 07*s*. 07*d*.
With six bottles of Wine."

This appears to have been an official present on taking office. Another connected with the same incident is "An 100lb. weight of biscuits to treat the Masters of Art in Oriel Hall;" this rather dry treat was, perhaps, to be moistened with some of the "six doz. of mountain-wine, very old and good," that figures in the account four days previously. Olives seem to have been important elements of conviviality. White bought them first of all in plates varying in price from a shilling to half-a-crown, but probably found these retail purchases too expensive, for, subsequently, we find him getting his olives in bottles from London. The olives, apparently consumed with punch, appear repeatedly in the account, generally for the entertainment of visitors—thus his cousin, "Bappy Isaac," figures two or three times in connection with that beverage, as also do the Mulsos, father and son, for whose refreshment we find five-shillings' worth of punch charged. This exuberance of hospitality in behalf of these last gentlemen may have had its origin in White's affectionate remembrance of Miss Mulso, for whom he had a *tendresse* in early days. The lady, however, preferred a rival, and is well known in literature by the name of Mrs. Chapone. Occasional references to tavern dinners and other jollifications of the same nature occur, and, altogether, we may infer that the Junior Proctor in the University of Oxford, in 1752–53, spent a tolerably merry time when his duties called him to that city. Other items serve to throw more or less light upon various social matters, espe-

cially the mode and cost of travelling, the rate of wages, &c., in the middle of the last century, but for these we must refer the reader to the original work.

The remainder of this volume is occupied by a "Garden Kalendar," kept by White at Selborne, a description of a fire-escape invented about 1788 by a Mr. Dufour, and tried against the front of Benjamin White's house in Fleet Street, and some supplementary matter. The latter includes lists of the most noteworthy animals and plants observed in Selborne and the neighbourhood, compiled, with assistance, by the editor; a very short note on the geology of Selborne by Mr. William Curtis; and an appendix by Lord Selborne, on the Roman-British Antiquities of the parish, the last relating chiefly to a find of nearly 30,000 coins of various emperors, from Gordian the younger to Allectus (A.D. 238–296), found here in 1873. From this and other evidence Lord Selborne believes that in the basin of Woolmer Forest we have the scene of the final overthrow of the British Army under Allectus.

The illustrations, which are not numerous, consist chiefly of steel plates of houses and views about Selborne, rendered interesting by being referred to by White. The appendix on the antiquities of Selborne is also illustrated with a coloured plate showing some curious mediæval (thirteenth century) tiles found in Selborne Church during its restoration.

We cannot conclude this notice, already, perhaps, rather too long, without congratulating Mr. Bell on the completion of what we know has been to him a labour of love, but, nevertheless, a labour, the last stages of which, at all events, must have been irksome enough to one who has long since passed the Psalmist's allotted period of human life. That he has done his work well, and with a true appreciation of the merits of his author, we have already endeavoured to show, and we can only hope that he may have good evidence that the reading public are interested in the result.

THE *POLARIS* ARCTIC EXPEDITION.*

THE expedition of the U.S. ship *Polaris*, which left Washington on the 20th June, 1871, and of which this handsome volume gives the history, was as successful in its early career as it proved to be unfortunate in its termination. Its Commander, Capt. C. F. Hall, was in every way fitted to undertake the charge of the expedition, having had great experience in Arctic travelling, and having, moreover, spent nearly eight years amongst the Esquimaux. Living with them in their houses, and following their mode of life, he had gained a knowledge of their language, and an insight into their customs, which could not but have proved of the greatest service to him in the arduous task he had set himself of planting on the Northern Pole of our hemisphere the stars and stripes of the United States. To his representations to the Government, and to enthusiastic lectures in many parts of the States, was due the appropriation of 50,000 dollars, granted

* "Narrative of the North Polar Expedition. U.S. Ship *Polaris*, Captain Charles Francis Hall, Commanding." Edited by Rear-Admiral C. H. T. 4to. Washington. 1876.

by the American Senate for furthering the progress of Arctic exploration, and for the discovery of the North Pole; and by his energetic exertions, the *Periwinkle*, afterwards christened the *Polaris*, was fitted and equipped for the voyage in a manner more complete than had ever before been accomplished. Besides the ordinary ship's officers, the expedition took out men of science qualified to report upon the Natural History, Meteorology, and Geology of the region visited, and to observe such Astronomical phenomena as might present themselves, the scientific staff being under the direction of Dr. E. Bessels.

Capt. Hall had at first contemplated proceeding by Jones' Sound, but subsequently found cause to abandon this intention, and eventually steered his course for Smith's Sound, which he reached on the 28th August, and which he found, contrary to all previous experience, quite free from ice. On the next day he reached his highest sailing point, which was afterwards determined by the U.S. Hydrographic Office to be in lat. 82° 11′ N. Here it was that the troubles of the expedition fairly commenced, and the *Polaris*, beset by ice, was drifted towards the south until she was finally brought to anchor in a bay subsequently named "Thank God Harbour," in lat. 81° 38′ N. From this place Capt. Hall made what unfortunately proved to be his last journey towards the north, travelling a little beyond Cape Brevoort in about the 82nd degree of latitude, on his return from which he was attacked by sickness, which terminated fatally on the 8th November, 1871, when the command of the expedition devolved upon Capt. Budington and Dr. Bessels conjointly, and under their charge various sledge and boat journeys continued to be made or attempted towards the north.

With the summer of 1872 efforts to reach a higher latitude in the *Polaris* were renewed; and though she had received severe injury from the "nips" to which she had been subjected, and when sawn out of the ice leaked so badly that it was necessary to keep the pumps constantly at work, she was got under way, but failing to make progress she returned to "Providence Berg," a stranded iceberg of large size, which afforded considerable protection to the ship when anchored under its friendly shelter.

At length, further progress towards the north being deemed impossible, the commanders reluctantly determined to make their way south, and finally left their harbour of refuge on the 12th August, 1872, having then in the bunkers only coal sufficient for six days' steaming. Constantly encountering close and impenetrable packs, the *Polaris* was at last moored to a large floe, with which she continued to drift, and on which a store-house was erected and a large quantity of provisions deposited in case of accident to the ship. Before this labour was brought to an end the high winds of early spring arose, which, breaking up the already weakened ice, forced the ship away from the party at work near the store-house, leaving a large part of the crew and many Esquimaux afloat upon the large floe, or upon smaller ones in its immediate vicinity. The *Polaris* continued to drift, chiefly in a southerly direction, until in the middle of October she was driven ashore, when the party on board forsook her, and passed the winter in a hut which they built on land; in June of the following year they once more set out on their return journey in boats which had been built by one of their party, and three weeks afterwards were picked up by the *Ravenscraig*, which carried the rescued crew to America.

Left alone at the mercy of the winds and waves, with boats which they had little or no opportunity of using, and with a supply of provisions so small and precarious as to render the utmost care imperative, the position of the unfortunate party on the floe, consisting of nine of the *Polaris'* men, and ten Esquimaux, appeared almost hopeless. At times remaining stationary, at others moved backwards or forwards by the ever-varying winds and currents, with ice on every side of them packed so closely that progress in the boats became impossible, almost without wood for fires, and presently so short of provisions that uncooked seal meat, with the skin and hair attached, was greedily devoured, and the men on watch were so demoralized by want and privation that they stole from the small remaining stock of food, while their comrades endeavoured to forget in sleep the perils of their situation, nothing was needed to increase their despair and hopelessness, when, in the spring of 1873, the ice began to break up and the miserable party found themselves on the mere remnant of the immense floe upon which they had taken refuge. For more than a month they remained in this situation, hesitating whether to trust themselves to the ice-floes which were now occasionally washed by the sea waves, or to their only remaining boat, when on the 27th April their hopes were raised by the sight of a steamer, which appeared to acknowledge the signals of the sufferers, but which did not in fact perceive them, and disappeared in the darkness, leaving them for two more weary days to the mercy of the elements, when they were observed and rescued by the *Tigress*, on the 30th April, and were carried back to civilized life.

Being only a record of the progress of the expedition, taken from the various journals of the different members of the staff, there is little of a definitely scientific nature in this work, but the narrative is clear, and in the main interesting, though savouring somewhat of official red-tape. It is illustrated by numerous maps and engravings, the latter of which are well executed, and convey to the mind a most vivid realization of Arctic scenery. We have already had occasion to speak in high terms of the admirable manner in which works published by the American Government departments are got up; and this is no exception to the rule: the type, printing, and paper are all excellent, and if the book is at times perhaps a trifle uninteresting to the general reader, owing to the minuteness of detail, it may on this account prove of all the more service to future explorers in Arctic regions, conveying a true, if not a very lively, idea of the difficulties which are met with, in language which, if it cannot be commended for absolute elegance, is, at least, free from affectation, and from the high flown or "slangy" style too common amongst authors on the western shores of the Atlantic.

THE BARENTS RELICS.*

THE translation of Mr. De Jonge's report upon the relics of the Arctic Explorer, William Barents, lately recovered by Mr. Gardiner, from Nova Zembla, with a brief explanatory preface by the translator, Mr. Van Campen, has produced a little volume of considerable interest, not only to

* "The Barents Relics: recovered in the Summer of 1876, by W. C. Gardiner. Described and explained by J. K. J. De Jonge." Translated, with a Preface, by S. R. Van Campen. 8vo. Trübner & Co., London, 1877.

geographical, but, perhaps more particularly, to historical students. Mr. Van Campen gives a short account of the expedition of Barents and Heemskerck, which set out from Amsterdam as early as the year 1596, having for its object the discovery of a northern route to China, but which was forced, by stress of weather, to fix its winter quarters on the inhospitable shores of Nova Zembla, where a hut was erected, from which, after a lapse of almost three centuries, many interesting remains have been recovered, and brought back to the fatherland of the adventurous Hollanders. Amongst these relics is a "scroll" signed by Barents and Heemskerck, giving a brief account of the objects of their voyage, and relating the hardships to which they had been subjected; and the dilapidated remains of several books, both printed and in manuscript, from which, however, little further information of the travellers can be gleaned. The printed books, which are for the most part collections of songs of a religious and sentimental character, are nevertheless of interest as indicating the means by which, no doubt, the hardy Dutchmen tried to while away the tedium of their long imprisonment. Besides these, there are many domestic utensils, and a "package of tallow candles, eighteen in number, consisting of nine to the pound; undoubtedly the oldest candles in the world—still they are able to give light."

One result of the observations of Mr. Gardiner, or rather of his predecessor in discovery, Captain Carlsen, has been very considerably to alter the geographical position of the north-east point of the island of Nova Zembla, which was found "to extend upward between 66° 31′ and 69° E. long., instead of lying in 76°, as was laid down in the latest charts." A map showing this change, and also a fac-simile of the "scroll" above referred to, are inserted in the book.

SCIENCE AND THE STATE.*

SOME weeks ago a series of extracts from a discourse delivered at Munich, by Professor Virchow, was published in the "Times," and attracted a good deal of attention. Mr. Murray has now published a translation of the entire discourse, which we cannot but regard as a most important and opportune expression of opinion on the part of one of the greatest of German *savants*.

This discourse has been regarded by many as a knock-down blow to the doctrine of evolution. It is, however, nothing of the kind; indeed it can hardly be said to be written in opposition to that doctrine, the admissibility of which, in some particulars, would seem to be accepted by Professor Virchow. We may refer more particularly to the reference at page 62 to the occurrence in North America of the "fossil ancestors of our horses, in regions where the horse itself has long since entirely disappeared;" and in other places the probability of the origin of organic forms by a process of evolution is distinctly admitted.

What Professor Virchow set himself to do in this discourse was simply to enter a protest against the doctrine of evolution (*die Descendenztheorie*), being regarded as founded upon a secure basis. He considers it to be still

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* "The Freedom of Science in the Modern State." By Rudolph Virchow, M.D. 8vo. London: John Murray, 1878.

in the position of a hypothesis wanting proof, and objects strongly to it acceptance as an established theory, and especially to the consequences whicl have been drawn from it as such by the monistic philosophers of Germany consequences which, as we all know, tend completely to revolutionize all ou ideas and practically amount to the establishment of a new religion and new philosophy. His protest, in fact, which was called forth by discourse delivered on previous days by Professors Häckel and Nägeli, and by Dr Klebs, is, as he himself tells us, a "protest against the attempts that ar made to proclaim the problems of research as actual facts, the opinions c scientists as established science, and thereby to set in a false light, before th eyes of the less informed masses, not merely the methods of science, but als its whole position in regard to the intellectual life of men and nations. Such a course, especially if the doctrine be expanded to the extent advocate by Professor Häckel and others, would, he holds, endanger that freedom o scientific opinion of which Professor Häckel's own discourse furnished a mos striking example; and he considers that the teaching of such opinions in th schools as established truths, which was advocated by Professor Häckel, i very much to be deprecated.

We must confess that we perfectly agree with Professor Virchow in hi general argument, and more or less in the opinions which he expresses upo the subject of evolution, which he regards as still an open question, but un doubtedly as possessing strong *primâ facie* claims to acceptance. In these day we have got beyond the old scholastic reasoning, according to which a phil sopher established his own theory by the mere fact of demolishing h opponent's, and we can admit that a cause may have right on its sid although its champion has weak places in his armour which he is not suffi ciently skilful of fence to defend from the blows of his adversary. Profess Virchow endeavours rather to indicate some of these weak points than t invalidate the doctrine of evolution; but at the same time he objects strongl in the interests of science and not of theology, to the extreme dogmatis displayed by some of the most advanced evolutionists, who would have u believe that the origin, not only of organic forms but of the universe itse has been fully explained. The translation appears to be remarkably we done.

THE VERTEBRATES OF AMERICA.*

WE have received from Professor Marsh a copy of a discourse on t Introduction and Succession of Vertebrate life in America, deliver by him before the American Association for the Advancement of Science, August last. It is manifestly impossible within the compass of a sing lecture to discuss in anything like detail a subject so vast, but Profess Marsh has succeeded in sketching out, in a most interesting fashion, t leading events in the history of the vertebrate type in America, where, as well known, some sections, especially, of that sub-kingdom, are represented an astonishing abundance and variety of remains. Professor Marsh definite accepts the theory of evolution, and endeavours, where possible, to indica the probable lines of descent of the great groups of vertebrates.

* "Introduction and Succession of Vertebrate Life in America." B Professor O. C. Marsh. 8vo., 1877.

SCIENTIFIC SUMMARY.

ANTHROPOLOGY.

Shell-Mounds in Japan.—Professor E. S. Morse has communicated to the Boston Society of Natural History an account of an ancient shell-mound discovered by him at Omori, near Tokio, in Japan. In general the deposit resembled those described by Steenstrup, in Denmark. The implements found in it were mostly of horn; only three rude stone implements were discovered. The pottery showed a remarkable variety of ornamentation, though it was very rude in character. In the incised character of the markings it recalls the pottery of the east coast of the United States; whilst in the raised knobs for handles, on the edge of the vessels, it shows the closest resemblance to pottery discovered by Professor Hartt, in Brazil. Professor Morse was uncertain whether these are traces of early Ainos, or of a race which preceded the Ainos and was displaced by them during their occupation of the island from the north.—*Silliman's Journal*, February, 1878.

The Language of Deaf Mutes.—At the meeting of the Anthropological Institute on March 12, Professor A. Graham Bell read a paper "On the Natural Language of the Deaf and Dumb." He regarded dumbness as, in most instances, a consequence of deafness, arising not from any defect in the vocal organs, but from an inability to acquire articulate language due to the want of the means of imitating it. He said that the dogma "without speech, no reason," was well founded, for deaf-mute children think in pictures, from which they form a language of signs, which, as contractions of it become understood, develops into a conventional language, but this is always very limited. No deaf-mute has been found who had formed the idea of a Supreme Being. About the commencement of the present century the Abbé de l'Epée established an institution for the education of deaf-mutes, and the tendency of the instructions there given was to render the language more and more conventional by means of contractions. The result of systematic education has been to enable the deaf-mutes to form a community among themselves, employing a real language capable of representing abstract ideas as well as objects, and even possessing peculiar idioms of its own—for example, the objective case is placed first, thus: "the boots made the bootmaker." This is a difficulty, and perhaps due to a mistake in the education, but it furnishes an interesting subject for anthropological inquiry into the analogy with the development of spoken language. The North American Indians have a sign language, but less developed than that of the deaf-mutes. The language of the deaf-mutes is beginning to split into dialects.

ASTRONOMY.

Transit of Venus in 1874.—As we anticipated, Mr. Stone, Astronomer Royal at the Cape, does not accept the result deduced from the observations of the last transit by the Astronomer Royal for England. He has, in fact, obtained from the same series of observations, dealt with in a different manner—that is, interpreted differently—a solar parallax of about 8″·89, corresponding to a mean distance somewhat less than 92 million miles, or less than the result obtained by Sir G. Airy by nearly 1½ million miles. At a recent meeting of the Astronomical Society it was stated that Capt. Tupman had obtained precisely the same result as Mr. Stone by a particular interpretation of the observations made in December 1874. It is not, however, to be inferred that on this account Capt. Tupman either accepts Mr. Stone's estimate, or entertains any doubt as to the validity of the result obtained, nominally by Sir G. Airy, but in reality by himself, from the British transit operations of 1874. On the contrary, Capt. Tupman's announcement was intended as a jocular way of intimating how little reliance could be placed on Mr. Stone's estimate. But certainly the joke was one which told in two ways; and in the minds of those who are not prejudiced in favour either of Mr. Stone's views or Sir G. Airy's, will be held to show that almost any value between the limits of about 91½ million and about 94½ million miles can be obtained from the observations, according to the manner in which they are interpreted.

Distribution of the Fixed Stars in Space.—Mr. Sidney Waters has contributed a valuable chart to the proceedings of the Astronomical Society, representing the results of Sir J. Herschel's star gauges of the Southern Heavens, given in his Cape of Good Hope observations. The chart is on the equal-surface projection. The map was divided into 20 minutes in R.A., and 3° in P.D.; and the results of the gauges figured in their proper places; the areas of the spaces were calculated, and the average of the gauges falling on each space multiplied by its area, the result being dotted as nearly as possible equably over the space. Nearly all the spaces were covered in this way; but in those cases where no gauges fell the average of the surrounding spaces was taken. The number of stars marked in the map is very small compared with the number actually existing, but the chart represents with sufficient accuracy the distribution of stars over the Southern Heavens down to the faintest stars visible in Sir John Herschel's 18¼-inch reflector. The stars visible to the naked eye were afterwards added. "The teaching of the chart," says Mr. Waters, "does not confirm the results of Mr. Stone's investigations, published in the 'Monthly Notices' of last March. The great massing of stars in parts of the Milky Way, its complicated form, and the sudden decrease of stars at its borders, are facts not consistent with the view that we are merely looking through an immense depth of stars, or that distance is the principal reason of their faintness. It is not denied that brightness is an important factor in the determination of stellar distances; but the point contended for is that it is not a sufficient basis upon which to found any theory of the construction of the heavens. The fainter stars increase at a far greater rate than would be the case if Mr. Stone's view were correct;

and the theory that the stars are distributed with any uniformity, either as to space or dimensions, is not in accordance with the teaching of that chart which I now beg to lay before the Society." The results obtained by Mr. Waters, in fact, confirm very effectively the views indicated by Mr. Proctor. By the way, we have been asked whether at p. 98 of our last number, correct dates are assigned to Mr. Proctor's papers on stellar distribution, as, if so, *he* cannot have borrowed from *M. Flammarion*. "It will go near to be thought so, shortly." The dates are correct.

Cyclonic Arrangement of the Solar Granules.—The splendid solar photographs taken by Dr. Janssen at Meudon show among other interesting features a tendency of the solar granules to arrange themselves in a spiral form, accompanied by more or less loss of distinctness of outline of the individual granules, an appearance suggesting great cyclonic disturbance of the part of the solar atmosphere in which these bodies lie. Mr. Huggins puts on record a similar appearance observed by him telescopically in 1866. His notes, made at the time, run thus: "Saw distinctly the granules. A spiral band of closely associated granules, ending in one of larger size. In one area near the centre of the sun's disc the granules appeared more elongated than usual, rather sparsely scattered, and the larger diameters very nearly in the same direction. In neighbouring areas the granules were smaller and less elongated. Amongst these no general direction was observed."

The Bright Line Spectra of Irresolvable Star Clusters.—Mr. Stone gives an explanation of his remarkable paper on this subject (recently communicated to the Royal Society), from which it appears that Professor Stokes and Messrs. Huggins and Proctor altogether misapprehended the purport of Mr. Stone's communication. His earlier statement ran thus: "The sun is known to be surrounded by a gaseous envelope of very considerable extent. Similar envelopes must surround the stars generally. Conceive a close stellar cluster. Each star, if isolated, would be surrounded by its own gaseous envelope. These gaseous envelopes might, in the case of a cluster, form over the whole or a part of the cluster a continuous mass of gas. So long as such a cluster was within a certain distance from us, the light from the stellar masses would predominate over that of the gaseous envelopes. The spectrum would, therefore, be an ordinary stellar spectrum. Suppose such a cluster to be removed further and further from us. The light from each star would be diminished in the proportion of the inverse square of the distance; but such would not be the case with the light from the enveloping surface formed by the gaseous envelopes." And so forth. It was mistakenly supposed by the trio above named that Mr. Stone was here referring to effects produced by varieties of distance; but it appears he was considering really the effects of the physical aggregation of such clusters. "The clusters which I had under contemplation were physical clusters, and this isolation of the gaseous surroundings would be, under suitable conditions, destroyed by the relative gravitation and heating effects of the several members of the system. It is to such a cluster only that my reasoning applies; and I think such will be seen to be the case if my paper is carefully read,"—"between the lines," he should have added. We would not for a moment question Mr. Stone's statement that his meaning was that which he now indicates. There can be nothing more discourteous and there are few things more unjust than to

question the explanation which a writer offers of his own words. But it must, we think, be conceded that Professor Stokes and Messrs. Huggins and Proctor had some reason for understanding Mr. Stone's paper as they did, and that among the many excellent scientific qualities possessed by the Astronomer Royal at the Cape, the power of clearly and unmistakably indicating his meaning must not be included.

Specular Reflexion from Venus.—Mr. Christie, assistant observer at Greenwich, continues to surprise students of science by the support which he gives to certain utterly preposterous notions respecting the celestial planets, which have been advanced of late by an admirable landscape painter, who seems very little acquainted with astronomical and optical laws. He now advocates the theory that Venus has a surface not merely possessing the power of reflecting light specularly, but also having metallic brightness and hardness. Although this theory is one of those which not only cannot be accepted but cannot seriously be attacked (standing somewhat on the footing of the older absurdity that the moon is made of green cheese, a theory never yet oppugned to the best of our belief), yet it seems to us that the observation on which the absurdity has been based is worthy of attentive consideration. It is this, that the brightest point of the disc of Venus, when the disc of the planet is gibbous (and recently the same has been found to be the case when the disc is crescent-shaped) lies within the limb, in about the position where an image of the sun could be seen if Venus had a metallic (and properly polished) surface. These observations have been confirmed (and some of them originally made) at Greenwich by Messrs. Christie and Maunder, and by Captain Tupman. Thus on January 9 and 10, 1878, "I had," says Mr. Christie, "an opportunity of examining Venus in the daytime, and I was fortunate in securing Captain Tupman's co-operation on these occasions. As seen with an ordinary eyepiece (power 500), Venus appeared as a crescent having a breadth equal to about two-thirds of the radius, with a bright arc near the limb. This arc shaded off perceptibly towards the cusps. On applying the solar eyepiece, which reduces the light (by virtue of the three reflexions from the glass) to one 3000th part, both Captain Tupman and I satisfied ourselves that there was a bright elongated patch distinctly within the limb. In the centre of this I caught glimpses of a small point of light, the distance of which from the *apparent* limb I estimated as rather more than 0·1 of the radius. The position of the point at which specular reflexion would take place I afterwards found by calculation to be 0·18 of the radius within the limb." Captain Noble had in June, 1876, under similar conditions of illumination, failed to detect any gradation of light whatever towards the limb. He recognized a patch of sensible area "without the slightest sign, trace, or indication" (we are not sure what distinction is intended to be drawn here between signs, traces, and indications) "of one part being in the smallest degree brighter than another." Mr. Christie considers that had Captain Noble looked more closely, he would perhaps have detected in the middle of the bright patch a small bright point as Mr. Christie did. Be this as it may, what Captain Noble saw, while certainly inconsistent with the theory that Venus has a simply rough surface or *mat* surface without any specular reflexion whatever, and equally inconsistent with the theory that Venus has a purely specularly reflective surface, in which case we should

not see Venus at all, but only the image of the sun in the Venerian mirror —it certainly is not correctly described by Mr. Christie as incompatible with any theory whatever. For, if the part of Venus turned earthwards at the time were covered with a great ocean, not so much rippled that the surface lost its power of specular reflection, while all the reflected images of the sun were distorted and scattered as we see them when the sun is shining athwart a rippled sea, an area of sensibly uniform illumination would be presented within the illuminated crescent of the planet's disc. A small portion near the middle of this area would be more brightly illuminated than the rest however, and if this were seen it would present the appearance of a point of light such as was seen by Mr. Christie. Certainly in the present condition of our knowledge respecting Venus, which assures us that she has an atmosphere like that of the earth, and at times very heavily laden with the vapour of water, the idea of a wide expanse of ocean surface, capable of specularly reflecting the sun's rays, and even "in seasons of calm weather" of making a nearly perfect, though at our distance an undiscernible, image of the sun (mirrored on that calm Venerian ocean), seems not only admissible, but altogether probable. The metallic surface, with its vitreous atmosphere, or as it has been called "the glorified thermometer-bulb theory," outrages common sense. Yet we find Mr. Christie, a mathematician of no mean skill, and as a practical observer free one would suppose from those tendencies which affect the *merely* mathematical mind, calmly presenting the fact that the position of the plane of polarization in the eyepiece relatively to the line of cusps appeared to have no appreciable effect on the gradation of light, "would be consistent with the theory of reflexion from a metallic surface." It would be consistent also with the theory that the spirit of the late Lord Rosse has during the last few years superintended the envelopment of the surface of Venus with a coating of speculum metal, alloyed in proportions corresponding to those used for the Parsonstown telescope; and it would be as well worth while to oppugn one theory as the other in any serious manner.

Meteoric Radiant Points.—Scarcely less absurd in its theoretical aspect, but equally useful as presenting observational facts of interest, is Mr. W. F. Denning's paper on the suspected repetition of outbursts from Radiant Points, and on the long duration of meteor showers. Noting that meteors seem to radiate for three or four months from the same radiant points, Mr. Denning, who has collected a considerable number of independent observations bearing on this point, mentions it as suggesting reasons for believing that the same meteoric systems really are traversed by the earth during these long periods of time. He says at the outset of his paper, that, "in the present very imperfect state of our knowledge it would be wrong to hastily condemn any observed facts, however improbable and incomprehensible they may at first sight appear." Condemning observed facts is certainly not a proper course for the true student of science; nor would it avail much, facts having a certain obstinate persistence, despite any amount of condemnation. There is, however, no easier way of bringing facts into question than basing utterly absurd and untenable propositions upon them. This is what Mr. Denning has done in the present instance. It is in the first place absolutely impossible that meteor systems should have the extension demanded for them

by Mr. Denning; and in the second place if they had, it is certain that the observed effects would not be those on which Mr. Denning bases his theory. If the radiant of a meteor system in January, for instance, is precisely the same as the radiant of a meteor system in April, then it is certain that the first meteor system and the second meteor system are altogether distinct from each other. For the direction of the earth's motion, on which of necessity the position of a radiant depends largely, has changed in the interval through one quadrant, that is to say, the earth in April is travelling at right angles to the direction she had in January—the same being true of any two periods in the year separated by three months. Capt. Tupman, who very promptly indicated, at the meeting where Mr. Denning's paper was read, the utter incompatibility of Mr. Denning's theory, either with possibilities or with the facts on which Mr. Denning attempted to base it, has supplied some "remarks on Mr. Denning's paper," which immediately follow it (we are glad to see) in the "Monthly Notices," and in some degree save the Royal Astronomical Society from the discredit which papers presenting untenable and unscientific theories tend to bring upon it.

Transit of Mercury.—A transit of Mercury occurs on May 6. For centre of earth the times of contact are as follows—

	Mean time at Greenwich.		
	h.	m.	s.
External impact at ingress . . May 6	3	12	25
Internal „ „	3	15	32
Least distance of centres, 3′ 47″·4 . . .	7	0	4
Internal impact at egress	10	44	34
External „ „	10	47	43
Angle from North Pole for direct image—			
Contact at ingress	45° towards E.		
„ „ egress	100° „ W.		

As the sun sets at 7h. 28m., little more than the first half of the transit will be visible in this country.

Other Phenomena for the Quarter.—Venus will be at her greatest westerly elongation at 6 A.M., May 2; Mercury at his greatest westerly elongation at 7 P.M., June 2. None of the superior planets come into opposition during the quarter.

CHEMISTRY.

The Hydrocarbons formed by the Action of Acids on Spiegeleisen.—Cloëz has examined the products resulting from the action of dilute hydrochloric acid (spec. gravity = 1·12) on soft cast-iron containing 0·04 per cent. chemically combined carbon, and about 0·06 per cent. manganese. As some of the hydrocarbons enter into combination with this acid, sulphuric acid diluted with five times its weight of water was subsequently used. In one experiment 200 kilog. of iron were treated with acid, and this quantity yielded 1·64 gramme of oily hydrocarbons condensed in the first washing-bottle; 2·278 grammes of brominated hydrocarbons of the ethylene series; 8·532 grammes of hydrocarbons of the marsh gas series separated by means of sulphuric acid; 4·38 grammes of solid residue; and 5·408 grammes of

oily products, removed from this insoluble portion by alcohol, and subsequently precipitated by the addition of water. The hydrocarbons of the marsh gas series retained by the sulphuric acid were removed by decantation, washed with water, and dried with fused potash, and, subsequently, with sodium. When submitted to fractional distillation it was found that the first portion passed over at 155° C, then the temperature soon rose to 160°, remaining at that point for some time. The portions which distilled between 160° and 170°, between 175° and 190°, and during successive intervals of 20° up to 300° were collected separately. These quantities were further purified by subsequent distillation and eventually seven products were obtained, each of which appeared to have a nearly constant boiling point. These are all substances which are known and appear to be identical with bodies which have been isolated by Pelouze and Cahours from petroleum. They form the highest known members of the marsh gas series, which are characterized by their insolubility in fuming sulphuric acid, and by their behaviour with chlorine and bromine. The first distillate is dekane, $C_{20}H_{22}$, probably identical with diamyl; it boils between 155° and 160°, has a vapour density = 5·132 (calculated = 5·001), and a specific gravity = 0·76 at 15°; bromine water is without action on this substance; bromine, on the other hand, attacks it vigorously, as also does chlorine, forming substitution products. The next body, undekane, $C_{22}H_{24}$, boils at 178°–180°; it is a colourless very mobile liquid having a vapour density = 5·521 and a specific gravity = 0·769; sulphuric acid does not act upon it; with bromine and chlorine, however, it forms substitution products. The next four are: duodekane, $C_{24}H_{26}$, which boils at 195°–198°, has a specific gravity = 0·782, and is acted upon by bromine and chlorine; tridekane, $C_{26}H_{28}$, boiling at 215°–220°, having a specific gravity = 0·793; tetradekane, $C_{28}H_{30}$, with a boiling point of 234° to 238°, and a specific gravity = 0·812; and pentadekane, $C_{30}H_{32}$, which boils at 258° and has a density = 0·83. The last distillate is hexadekane, $C_{32}H_{34}$, boiling at 276°–280°; its specific gravity is 0·85. This body is attacked by fuming nitric acid, but no crystalline product was obtained. Many of the hydrocarbons, then, which are formed by the action of dilute acid on cast iron are identical with natural products contained in the complex material which we call petroleum (*Compt. rend.*, lxxxv. 1003). We are reminded here of Mendelejeff's views respecting the origin of mineral oils communicated last year to the Russian Chemical Society (see note in the "Pop. Sci. Rev.," July 1877, p. 317), and of the occurrence at Ovifak, Disko Island, Greenland, of vast metallic masses, possibly meteoric, possibly erupted, which contain much carbide of iron.

Persulphuric Acid.—Berthelot has prepared a new acid of sulphur (*acide persulphurique*), corresponding in composition with perchloric and permanganic acid, by the discharge of electricity of high tension, though a perfectly dry mixture of equal volumes of sulphurous acid and oxygen; sulphuric acid combines neither with oxygen nor with ozone under similar conditions. The electrolysis of concentrated sulphuric acid also yields the new acid in a state of solution. It can, moreover, be prepared in a state of solution by cautiously mixing a solution of hydrogen peroxide with sulphuric acid, concentrated or diluted with not more than one equivalent of water; when two equivalents are present no reaction takes place. In the last-mentioned case the reaction

appears never to be complete, a portion of the hydrogen peroxide always remaining unchanged. Anhydrous persulphuric acid is most readily prepared by allowing the discharge to take place for eight or ten hours through the tubes constructed for such operations, by which time their interior is found to be covered with drops of a viscous liquid: at 0° it becomes solid and is crystalline; in places it has a granular structure; in others thin transparent crystals are seen traversing the length of the tubes; brilliant scales are also observed attached to the glass. The acid resembles anhydrous sulphuric acid; the latter substance, however, forms opaque crystals which are shorter, much finer and narrower than them. At 10° persulphuric acid has a vapour tension of several centimètres, and sublimes spontaneously from one part to another of the tube in which it is confined. Its composition was determined both by synthesis and analysis. After the two gases had entered into reaction the residue was removed from the tube by means of the Sprengel pump and measured: if the change takes place in accordance with the following equation the residue should be one-eighth of the gas consumed:—

$$\underbrace{S_2O_4}_{4\text{ vols.}} + \underbrace{O_4}_{4\text{ vols.}} = S_2O_7 + \underbrace{O}_{1\text{ vol.}}$$

In two experiments the numbers 8·2 and 7·9 were arrived at in place of the ratio 8·1. Four volumes of sulphurous acid and three of oxygen, therefore, appear to combine to form persulphuric acid:—

$$S_2O_4 + O_3 = S_2O_7$$

The acid was analysed by several methods: by using a standard solution of tin chloride, estimating the change by means of potassium permanganate, and subsequently determining the sulphuric acid as barium sulphate; again, by employing a standard solution of ferrous sulphate, and afterwards observing the amount of a standard solution of permanganate required to complete the oxidation; also by the use of potassium iodide and hyposulphite, as well as by the employment of sulphurous acid and potassium iodide. Each method gave numbers which indicated the formula S_2O_7 as that of the new acid. At 0°, or at temperatures below zero, the acid may be preserved for some days; it is not a stable compound, however, and after the lapse of 14 days it commences to spontaneously decompose; the aqueous solution very rapidly undergoes change; when it is dissolved in concentrated sulphuric acid the decomposition is retarded; in this case also oxygen is slowly evolved, and at the end of six weeks the acid is completely destroyed. An application of heat causes it to separate into sulphuric anhydride and oxygen. It develops dense fumes in contact with air, atmospheric moisture is absorbed, and hydrated sulphuric acid formed. Dissolved in concentrated sulphuric acid it appears, as has already been stated, to have the power, for a time, of resisting decomposition; the solution, after the lapse of the first twenty-four hours, appears, from the results of volumetric analyses, to undergo no appreciable change. When placed in contact with baryta water a portion of the acid apparently escapes decomposition and barium persulphate is produced; the salt, which could not be analysed, is soon converted into the ordinary sulphate, oxygen being evolved. Persulphuric acid does not oxidize arsenious acid or oxalic acid in the cold, and in this respect it closely resembles hydrogen peroxide; a marked difference from that compound in other reactions in that it

unable to form perchromic acid and does not reduce potassium permanganate. The author concludes his very interesting paper with some speculations on the relation of the oxides of sulphur to those of other non-metallic and of metallic elements, and promises to employ his method in the investigation of the higher oxides of other substances.—*Compt. rend.*, lxxxvi. 20.

The Crystallization of Lime, Strontia and Baryta.—Brügelmann describes the chemical and physical characters of these oxides when in a crystallized condition ("Annalen der Chemie und Physik," ii. 466). The crystals are formed when the nitrate of the metal, enclosed in a porcelain flask or retort, is submitted to the very high temperature of a furnace fed with coke. All three of the oxides form crystals, belonging to the regular system, and they are invariably found to be cubes; in the case of lime, crystals having an edge one millimetre in length have been obtained. As a rule the residue left when a nitrate is treated in the manner described, has a vesicular or foliated appearance, and is apparently an amorphous mass; a low power, however, is sufficient to show that it is made up of crystals. An examination of crystals of each of these oxides in polarized light confirmed the observation that they all belong to the regular system. The lime produced from the nitrate is far less readily subject to change when exposed to the action of moisture or carbonic acid than that obtained by heating marble. These crystals (of lime) can be exposed to the air for many days without undergoing change, and to water or moisture for several hours before they fall to powder. That the materials in the hands of the author were pure oxides is proved by his analyses, which showed them to consist respectively of 99·64 per cent. of lime, 99·4 per cent. of strontia, and 99·32 per cent. of baryta.

Separation of Nitrogen from Air.—Harcourt and Lupton have found ("Chem. Central-Blatt," 1878, ii.) that in the removal of oxygen from air by passing it over red-hot copper turnings, a very large metallic surface must be exposed, since the reaction ceases when the crust of oxide attains a certain thickness. The authors compass the difficulty by conducting the air through concentrated ammonia before it reaches the copper; the oxide is in this way continually reduced. As long as the supply of ammonia is maintained a mixture of pure nitrogen and steam issues from the apparatus.

Composition of the Smoke of Virginia Cigars.—Schwarz has examined these gases by the aid of Orsat's apparatus, the use of which instrument he highly recommends for technical analysis. The products of the combustion of the tobacco were collected in an aspirator, and were found to contain 12·0 to 12·85 per cent. carbonic acid, and 4·0 to 4·76 per cent. of carbonic oxide. The presence of the last-mentioned constituent explains the deleterious action of these cigars.—*Chem. Central-Blatt.* 1878, vii.

Weights and Measures.—The German Federal Council issued, at the end of last year, a list of contractions which are to be employed in official documents to indicate the respective weights and measures, the names whereof are written beside them in the following table:

Kilometer . . .	km	Square kilometer .	qkm
Meter	m	Hectar . . .	ha
Centimeter . . .	cm	Ar	a
Millimeter . . .	mm	Square meter . .	qm

Sqnare centimeter	qcm	Cubic millimeter	cmm
Square millimeter	qmm	Ton	t
Cubic meter	cbm	Kilogramm	kg
Hectoliter	hl	Gramm	g
Liter	l	Milligramm	mg
Cubic centimeter	ccm		

No stops are to follow the letters. The letters are to be placed after the figures which express the amount, not over the decimal point: 5,37m, not 5m, 37cm. In separating the integral numbers from those representing the decimal part a comma is to be employed in place of a full stop. The comma is not to be otherwise used when writing numbers representing measures of weight or capacity, not as formerly to divide high integral numbers; in such cases the digits are to be divided into groups of three, counting from the comma (our decimal point), and the division between the groups is to be marked by a space. The new system has been introduced in the columns of the "Chemisches Central-Blatt." (See note in "Chem. Central-Blatt," January 2, 1878, xvi.)

GEOLOGY AND PALÆONTOLOGY.

An American Jurassic Ceratodus.—In the January number of "Silliman's Journal" Professor Marsh describes an interesting discovery he has made among the vertebrate fossils obtained from the same Upper Jurassic deposits of Colorado which furnished the gigantic Saurians noticed in our last number (p. 103). This is the left lower dental plate of a fish of the curious genus *Ceratodus*, which Professor Marsh names *C. Güntheri* in honour of Dr. Günther of the British Museum. The specimen has the inner side convex and the outer divided into five projections, separated by four notches, the upper edge showing five points, of which the foremost is the longest and most widely separated. The plate is attached to a fragment of the dentary bone, and furnishes the first evidence of the existence of *Ceratodus* in America in Mesozoic times.

Silurian Land Plants.—Professor Lesquereux has described (in the "Proc. Amer. Phil. Soc.," 19 Oct. 1877) and figured some terrestrial plants from the Lower Silurian. These are *Protostigma sigillaroides* from the Cincinnati group of Ohio; and *Psilophyton gracillimum* and *Sphenophyllum primævum* from the same rocks near Covington, Kentucky.

A Carboniferous Fungus.—In the above cited paper Professor Lesquereux also describes a fungus (*Rhizomorpha sigillariæ*) found upon a Sigillaria in Cannel coal at Cannelton, Kentucky.

New American Dinosaurs.—Professor Marsh now forms a new family, *Atlantosauridæ*, for the gigantic Jurassic Dinosaur noticed in our last number (p. 103), and indicates as its more important characters the pneumatic cavities in the vertebræ, the presence of only three or four vertebræ in the sacrum and the corresponding shortness of the ilium, the large fore-limbs, and the presence of five well-developed digits in both fore and hind feet. The [illegible] was ungulate and essentially plantigrade. The carpal and

tarsal bones were not co-ossified with the long bones, and the third trochanter of the femur was rudimentary or wanting.

Professor Marsh describes a still larger species of *Atlantosaurus* (*A. immanis*) which had a femur *over eight feet* long, which, taking a crocodile as a term of comparison, gives the fossil animal a length of about 115 feet; and the author thinks it probable that the reptile when alive was nearly 100 feet long, though it may have been much less. Another species, called *Morosaurus impar*, allied to *Apatosaurus* and *Atlantosaurus*, is best represented by its sacrum, which is said to indicate an animal at least 25 feet long. The genus *Allosaurus* (see p. 104) is said to present characters which render it the type of a distinct family of Dinosaurs, *Allosauridæ*, and a new species (*A. lucaris*) 18 or 20 feet long is described.

Creosaurus atrox, allied to *Lælaps*, an animal about 20 feet in length, is said to have been "the carnivorous enemy of the huge *Atlantosauridæ*." The teeth referred to it have more or less trihedral crowns, with the cutting edge crenulated. The vertebræ are biconcave.

As a contrast to the preceding giants we have *Laosaurus celer*, a Dinosaur about the size of a fox, and *L. gracilis*, a still smaller species.—*Silliman's Journal*, March, 1878.

Carboniferous Sponges.—Numerous remains of spicular bodies, believed to belong to sponges, have been recently detected in the Carboniferous shales of the south-west of Scotland, and described in more or less detail by Professor J. Young, Mr. J. Young, and Mr. H. J. Carter, in several papers published in the "Annals and Magazine of Natural History" (see especially ser. 4, Vol. XX., p. 425, and ser. 5, Vol. I., p. 128). The most interesting part of the evidence points to the existence in Carboniferous times of a sponge so nearly allied to the well-known glass-rope, that the above authors do not hesitate to refer it to the same genus, and it is here described under the name of *Hyalonema Smithii*. With regard to other species the evidence of affinity with recent forms is less striking. Mr. Carter has some important remarks on the replacement of silica by carbonate of lime in these fossils.

MECHANICS.

An Automatic Railway Brake.—In "Nature," March 21, 1878, we find a description of an automatic brake made by the Westinghouse Brake Company, and an account of some experiments on the action of a current of compressed air upon an elastic ball, which possess considerable interest. The article is really a report of experiments witnessed at the Company's offices, where the writer was shown the action of the whole apparatus necessary to stop a train of ten carriages. The apparatus works by means of air, which is compressed by a steam engine, and distributed through all the tubes and the ten reservoirs, extending over the whole length of the train; by simply turning a handle this compressed air acts upon the brakes, which, in turn, clasp the wheels; the action is so completely under control that the brakes can be applied in less than 5 seconds, and so powerful as to bring a train going 40 miles an hour to a dead stop in about 15 seconds, and within a distance of 500 yards.

The mode of action is as follows:—The compressed air is admitted i

cylinder containing the ends of two pistons, which act by leverage upon the brakes, the admission of the air being effected by means of a reduction of pressure, which opens a set of valves communicating with the cylinder. On its entrance it pushes the pistons out, and these then act upon the brakes. A further advantage is said to be that in case of the train breaking into two or more parts, the brakes will immediately act automatically and bring the carriages to a standstill. This brake is already in use on the Midland Railway.

The experiments above alluded to, with a hollow elastic ball, were made by means of a nozzle attached to the apparatus, through which the compressed air could be allowed to escape. When the ball is placed within the current of air, with the tap upright, it is sustained as if by a jet of water, but shows little or no revolving motion. When the tap is inclined at an angle of 30° or 40°, the ball is still supported by the current, but it recedes and advances in the line of the tap and revolves so rapidly as to cause a distinct flattening of its poles, and this goes on until the ball becomes almost a disc. The axis of rotation then gradually changes until it is at right angles to its original position, when the speed of rotation diminishes, and the ball gradually ceases to revolve; then it begins rotating upon its new axis, and passes through the same series of changes repeatedly so long as it is exposed to the action of the jet.

MINERALOGY.

The Accidental Coloration of the Zeolites.—The coloured varieties of these minerals may be divided into two groups: those owing their colour to the presence of inorganic material like the red zeolites of Dumbarton and the Fassathal, which enclose hydrated oxide of iron, and those which contain organic compounds. Websky ("Jahrbuch für Mineralogie," 1878, 75) has published a memoir on the mineral species which are included in the second category. The best known minerals of this class are the brown desmin and heulandite occurring in the deposits of magnetite at Arendal; here the colour is unquestionably due to the presence of an asphalt-like substance. Similar crystals have recently been met with in druses in the granite of Gräben. The desmin of Striegau exhibits pale leather-brown and wood-brown hues. The rare crystals of chabasite have an orange red approaching a chestnut-brown colour, very intense on their surface, lighter but still relatively intense in the interior. Chabasite appears to take up the largest amount of the colouring substance. A fragment of this mineral when heated in a closed tube turns black, a small amount of a tar-like substance distilling off. The mineral is afterwards found to have a pale grey colour; if heated for a longer time in an open tube the colour disappears, at least from the surface. Two specimens of heulandite from the granite of Striegau, now in the Berlin collection, exhibited two years ago a fine citron yellow colour, now they are much paler; others are referred to which were covered with perfectly colourless crystals of laumonite. It is curious to find that minerals, like chabasite, desmin, heulandite, and laumonite, which agree so closely as regards their elementary constituents, and differ only in the proportion of these ingredients, should exhibit a very great disparity in their

power of absorbing a colour-producing organic compound, and, in cases where this compound has been taken up by each variety, that they should differ in so marked a manner in respect to the action of light upon them.

Amber.—Rehoux has published a paper in a recent number of the "Annales de Chemie," on the means whereby this substance may be distinguished from artificial amber, copal, and other bodies. Copal is yellow, more or less deep in hue, which is of the same intensity throughout the specimen, and has on its surface yellow points resembling sulphur. Amber, on the other hand, has always one end of a different shade from the other. When rubbed on the palm of the hand for a few seconds, amber emits a powerful aromatic odour; the other substances show no change when treated in this manner. By prolonged exposure to air amber sometimes loses a constituent, which the author believes to be an essential oil, and its characteristic aspect is lost. When copal is scraped with a knife the fine particles go upwards; when amber is so treated what is detached falls. Amber, when gently heated in a flame, may be bent; the other substances are not pliant. Copal melts at 100°, preserving its yellow colour; amber fuses at 400°, and blackens, emitting a distinct odour of sulphuretted hydrogen. Amber has a specific gravity = 1·09, that of copal is 1·04, and that of artificial amber is 1·05. Yellow amber has the composition:—

Carbon	78·82
Hydrogen	10·23
Oxygen	10·90
	99·95

Bolivite and Taznite.—Domeyko has recently communicated to the French Academy of Sciences some further notes on the mineralogy of Bolivia. Bolivite is the name which he has given to a bismuth oxysulphide, composed of the protosulphide $Bi_2 S_2$, and of the sesquioxide $Bi_2 O_3$. Taznite is a chlor-arsenate and chlorantimonate of bismuth which has been found at Tazna, in Bolivia. Several curious bismuth minerals are referred to in his paper.

Bischofite.—This name has been given by E. Pfeiffer to a new mineral species from the salt deposits at Strasfurt. An analysis by König shows it to consist of 11·86 per cent. of magnesium, 35·04 per cent. of chlorine, and 53·10 per cent. of water. These numbers indicate the formula $Mg\ Cl_2 + 6\ H_2 O$ as that of the mineral.

Quartz and Tridymite.—Sandberger describes some curious crystals of quartz from the Friedrich Christian mine at Shapbach, which enclose spherules or partial spherules (hemispheres), white and opaque, of the size of a millet seed, and consisting of silicic acid. When examined under the microscope in polarized light, they proved to be small masses of opal, surrounded by little crystals of tridymite. The tridymite is here found associated with copper pyrites, dolomite, and other minerals, and the observation is of interest as affording confirmation of Vrba's statements respecting the occurrence of tridymite in quartz ("Jahrbuch für Mineralogie," 1878, 47). While studying the minerals of the Rocher du Capucin, near Mont Dore, last autumn, Des Cloizeaux remarked the occurrence of crystals of hypersthene, tridymite, and zircon in the druses of the trachyte of that locality. He finds that the tridymite readily undergoes change. Blocks of stone, hewr

in the preceding spring, contained crystals of that mineral which had beco altered, white and partially destroyed, the hypersthene remaining unchang In one locality he found a geode filled with crystallized, or rather crystalli doubly refractive quartz, much fissured and very friable, resembling that fr Radicofani, associated with which were a number of crystals of tridymite *Jahrbuch für Mineralogie*. 1878, 45.

Pandermite.—Vom Rath has given this name to a lime borate, wh occurs in the form of rounded nodules, associated with gypsum, in a bed clay-slate at Panderma, on the Black Sea. The new mineral resemble snow-white, finely grained marble, and appears to have a composit expressed by the formula 2 CaO. 3 $B_2 O_3$, 3 $H_2 O$, and to be nearly rela to the borocalcite of Toscana and Iquique.—*Jahrbuch für Mineralo* 1878, 75.

Sandberger communicated to the last "Naturforscherversammlung" a pa on the occurrence of traces of heavy metals in the minerals of the rocks closing metallic veins. Several specimens of olivine, hornblende, augite mica were observed to contain, in the form of silicates, traces of the me which entered largely into the composition of the metallic minerals traver or associated with them. In the picryte from the Carpathians and serp tine derived from it, a small amount of nickel and a still smaller quan of cobalt were met with. Copper occurs in the olivine of Naurod and the Ultenthal, as well as in the palæopicryte of the Fichtelgebirge and Dillenburg. The latter mineral contains, moreover, a trace of bismuth. hornblende and augite, copper and cobalt were found. Specimens fi Andreasberg were examined, and the presence in them of traces of l antimony, arsenic, and nickel, was recognized. Some micas contain as stituents lead, copper, cobalt, and bismuth; while in that variety of mineral which forms an ingredient of the gneiss of Hörstein, the presenc arsenic was detected.—*Rev. deut. chem. Gesell. Berlin*, January 14, 1 2233.

PHYSICS.

Note on some Phenomena of Electrolysis.—I have much pleasure in furn ing the following note of some experiments, a preliminary notice of w was given to the Physical Society of London, on the 16th of March of year.

Amongst the well-known effects of passing a current of chemical ele city through a non-metallic conductor are:—(1) Electrolysis, whereby electrolyte is divided into primary and secondary products which, spea generally, bear to one another and to the electrodes a relation homolo with that which the metals in the active cells bear to one another an their liquids. (2) There is a bodily carrying-forward of the whole ele lyte in the direction of the current, and this is more marked accordin the electrolyte is a worse conductor. (3) There is an action compou of the above two. If sulphuric acid be electrolysed, the acidity is incre around the + electrode. If caustic soda be electrolysed the causticit augmented around the − electrode. If sulphate of copper be electrol

between platinum poles, copper (as sulphate) travels to the − electrode, but not in sufficient quantity to replace that which is there deposited (Hittorf, Wiedemann).

Remembering the molecular indifference which crystalloids and colloids bear to one another, the question presented itself:—Is there, in a mixture of the two kinds of matter, sufficient continuity and mobility amongst the crystalloid molecules to establish an electric chain? If there be so,—molecular currents being wholly suppressed by the colloidal obstruction,—a valuable means would be furnished for tracing the "wandering of the ions."

Water was boiled with sufficient gelatine to form a stiff jelly. In this, while warm, a little sulphate of sodium was dissolved together with some litmus. To one portion a drop of dilute sulphuric acid was added, to another a drop of ammonia. When the jellies had set in glass cells, pairs of sheet platinum electrodes nearly fitting the cells were thrust in, about two inches apart in both cases. Six pint platino-zinc battery cells were attached to each (in succession). Flattened bubbles of gas forced themselves up from both poles with a crackling noise. In a quarter of an hour, in the slightly reddened cell, both faces of the + electrode were clothed with a brighter and more transparent red envelope, but somewhat thicker towards the other electrode. The − electrode was coated with a transparent blue envelope. These two conditions spread and met one another in about three-quarters of an hour, in a vertical plane between the two electrodes, somewhat less than twice as far from the − as from the + electrode: the blue band being the widest. This plane was maintained for three hours after its establishment with the current in action, and kept the same for days after the current had been broken; although by automatic diffusion, the blueness and redness have spread backwards. A similar effect was produced in the blue jelly. The heat developed produced a slight fusion, which was confined to the − electrode.

F. GUTHRIE.

A Point in the Theory of Brass Instruments.—A paper was read before the Physical Society, by Mr. D. J. Blaikley, on this subject. The common description of such instruments as cones, or cones combined with cylindrical tubing, was objected to as being inaccurate, as was also the opinion that horns, trumpets, &c., have naturally, of necessity, just intonation, or notes with vibrational numbers, 1, 2, 3, 4, &c., corresponding to the prime, octave, twelfth, double octave, &c. The two simple forms of resonators that give these intervals, the open tube of equal section and the complete cone, were shown, and the positions of their nodal points explained. The positions of the nodes in the cone were experimentally determined by a method which is believed to be new, and is peculiarly applicable to tubes of varying section. The conical or other tubes, the nodes of which were to be determined, were immersed in water, until the length giving the maximum resonance to a vibrating fork of the required pitch, held over the tube, was fixed by the water level. It was then shown that the action of the lips does not, at least to any material extent, affect the conditions of resonance. Various truncated cones, with and without the addition of cylindrical tubing, were then blown by the lips; none of them gave the required harmonic intervals, and it was demonstrated that this was because the position of the lips did not correspond to that of a nodal point common to all the points required. The positions of

the nodal points in a bugle of hyperbolic figure, giving the correct intervals, were then shown experimentally and explained; the difference in position between these and the nodes of similar notes on a cone being very great. The bugle used had for the pitch of its prime or fundamental note C of 128 vib., and was divided into seven semi-ventral segments for C of 512 vib. This C could be produced from each of these seven pieces, or from any combination of an odd number of adjacent pieces, and the effect of the gradual increase of curvature from the mouthpiece to the bell upon the positions of the nodal points, and consequently upon the lengths of the semi-ventral segments, was thus made apparent.

Telephonic Signals.—The telephone, wonderful instrument as it is, is still far from realizing the ideas entertained of it by the general public, who are generally inclined to fancy that the extraordinary results foreshadowed by the facetious Mr. Punch have already been attained. It is still impossible for a serious family to remain quietly in their own drawing-room on a wet Sunday and satisfy their consciences by listening there to the suave eloquence of some popular preacher; for ladies of musical tastes to enliven their soirées with melodies "wired" from Covent Garden or the Haymarket; or for scientific amateurs to enjoy the discourses delivered for their delectation at the Royal Institution without the labour of travelling to Albemarle Street. Telephonic utterances sound as if they came "from the back o' beyont," to use an old Scotch phrase; and even these faint adumbrations of speech can only be perceived when the receiving instrument is held close to the ear of the listener. Hence arises a difficulty, namely, how is the intended recipient of a message to be warned that a communication is about to be made? for it is obviously too much to expect that the persons at the two ends of a telephonic line shall sit perpetually with the instruments applied to their ears. Mr. W. C. Röntgen indicates ("Nature," December 27, 1877) that a warning may be given by means of a battery and alarum attached to the telephonic system, but that this will cause so great an addition to the cost of establishing and maintaining a telephonic apparatus that it must be dismissed as inadmissible. His own plan is to give a signal of the intended transmission of a message by means of a tuning-fork placed close to the end of the bar magnet, opposite to that which acts in reproducing the vocal sounds. He proposes to effect this by providing the second pole with a coil of wire inserted in the circuit at this point, and connected with the general circuit in a manner easily understood but hardly explicable without a figure. "Before this pole of the magnet," he says, "may be very easily set up a tuning-fork, which, with the telephone, is simply fixed to a resonance case; this arrangement should be made at both the transmitting and receiving stations, and both forks should be in unison. If now the sending station wish to signal that a communication is to be begun, the fork of that place will be sounded with a fiddle-bow; the currents thereby induced in the coil are powerful enough to set the fork of the receiving station in such intense vibration that the sound may be distinctly heard in a large room." Mr. Röntgen says that he has made this experiment in a room containing about 100 people, all of whom could hear the sounds of the fork, which was a König Ut_4. The author has made some experiments which are of interest. One is of importance in connection

with the reproduction of the clang-tints of tones through the telephone. If in one of the two telephones a higher fork be substituted for the Ut_4 one and this is sounded with the fiddle-bow, "there will be heard with another inserted telephone of the ordinary construction tones of even 12,000 double vibrations per second, a sign that the variations of the magnetic condition of a magnet perceptibly occur, even when the forces producing these variations change their size 24,000 times in a second." In another case he used the telephone to test the electric vibrations indicated by Helmholtz and others as produced in the induced coil by the opening of the primary current of an induction apparatus, when the ends of the former are connected with the armatures of a condenser. The telephone was inserted in the circuit between the coil and the condenser. When the ends of the induced spiral were not connected with the condenser, he heard a dull report in the telephone; when these ends were connected with the condenser, this report was accompanied by a shorter, higher sound. The observations were made with a telephone having a very thin and deep-toned iron membrane.

At the meeting of the Academy of Sciences of Vienna, on February 14, Dr. J. Puley suggested another application of tuning forks to telephonic signalling. He proposes to remove the vibrating plates from two connected telephones when not in action, and to place opposite the coils the limbs of two tuning-forks of as nearly as possible the same tone. On the other side of each tuning-fork is placed a small bell, and between this and the fork a little brass ball is suspended so as to touch the latter. When the fork at either end is set in vibration by means of a small iron hammer coated with leather, the fork in the other station also vibrates, and sounds the bell by means of the little ball. When the signal is answered from the receiving station, the vibrating caps are put on the telephones, and conversation can be carried on. Dr. Puley has also made experiments with steel reeds, such as are used for the harmonium. With a resonance box, the tone is so strengthened at the receiving station as to be perfectly perceptible in a large room. The bell-signal is so loud as to be audible in an adjoining room with the door closed.

The Ultra-violet Spectrum has been studied by M. Cornu in a paper brought before the French Société de Physique, on February 15. He employs the ordinary ray from a prism of Iceland spar, which forms the more deviated and the more widely dispersed of the two spectra. He replaces the glass or metal reflector of the Heliostat by a prism of quartz giving total internal reflection. He uses quartz object glasses, ground specially for obtaining the minimum of aberration, the shape being that of a crossed lens, very nearly plano-convex, with its flatter curvature outwards. He concentrates the light on the slit by means of a convex lens also of quartz. It is thus found that the spectrum varies with the time of day, having a maximum about midday. It is longer in winter than in summer. To obtain the normal spectrum, he draws all the lines of the prismatic spectra on a large scale, then determines the wave-lengths of some, and calculates the others by interpolation. He also employs diffraction gratings, but substitutes in this case the electric spectrum of iron for that of the sun, which is of feeble intensity in the ultra-violet tract. He has carried this region somewhat further than had been previously done.

Lightning Conductors.—M. Melsens has erected a series of lightning-

conductors on the fine old Hôtel de Ville at Brussels. Instead of single rods he employs bunches or groups of points, branching out in all directions, connected with numerous ramified conductors meeting in a solid block of galvanized iron, from which three series of ramified wires sunk like roots in the ground are connected, one communicating with a well under the court, the two others passing through iron pipes full of gas tar, until they reach the gas and water mains of the town.

Toughened Glass.—An improved method of producing annealed or toughened glass has been adopted by M. de Labastie. He throws the soft articles, immediately on their being blown, at once into the annealing bath, so as to save a second heating, and the consequent danger of loss of shape.

Automatic Gas Lighting.—An ingenious plan for accomplishing this object has been brought before the Society of Arts by Mr. Fox. Each lamp is supplied with a small induction coil, the primary wires of all being united, and the secondary with condensers composed of glass plates and tin foil laid alternately side by side. The soft iron core of the induction coil is also used to produce reciprocating horizontal motion in a permanent horseshoe magnet suspended on needle-points just above the coil. A stop-cock is actuated by the reciprocating magnet, and thus the gas can be turned on immediately before the lighting spark passes. The whole apparatus is contained in an air-tight metallic case, measuring 2½ inches high by 2½ inches wide, screwed on to the supply pipe of the lamp, the insulated wire being either carried underground, or as in some experiments now in progress in Waterloo Place and Pall Mall, hung from small telegraph poles attached to the tops of the lamp standards.

The Compass of Ancient Flutes.—M. V. Mahillon has been able to reproduce successfully the tone and scale of the ancient flutes found at Pompeii.

A similar determination was made in 1876 by Mr. W. Chappell and Dr. Stone for facsimile copies of the Egyptian flutes preserved in the British Museum, and in that of Turin. These were exhibited and played on during the Loan Exhibition of Scientific Instruments at South Kensington. The reed then used was that which can be made from a simple joint of long grass by means of a longitudinal flap cut upwards towards the closed node. This, the most ancient form of reed, as described in "Tyndall on Sound," is often made by children in the fields, and called a "Squeaker," and still exists in the drones of the ordinary bagpipe.

M. Mahillon made use of a similar single beating reed, to be found in the *Arghoul*, or Egyptian flute. Taking for granted what is rather matter of doubt, namely that the chromatic scale was known to the ancients, M. Mahillon concluded that if the thirteenth sound obtained was the octave of the first, the intermediate notes must be correct. Thus B, on the second line of the Bass clef is obtained as the fundamental or lowest note of the instrument, and the following notes are successively obtained by opening the lateral notes, C sharp, D, E, F, F sharp, G, G sharp, G sharp, A, B flat, B natural. The absence of C and of D sharp is accounted for by the fact that the second and fifth rings of the instrument are not bored. It is possible this may be due to the fact that they would, if open, exceed the number of the digits, though M. Mahillon does not advert to this point. The

duplication of G sharp, however, throws some doubt on the correctness of the scale.—*Pall Mall Gazette*, March 18.

The Phonograph essentially consists of two parts, a recording instrument, and another for deciphering and reading aloud the record thus obtained.

The former has a mouthpiece stopped at its inverse end by a metallic diaphragm carrying a point. In close approximation to the point, a metal cylinder covered with tinfoil is made to rotate in a spiral. The tinfoil being left unsupported behind by a spiral groove of similar pitch cut in the cylinder, is indented by the point with depressions corresponding to the vibrations of the metallic plate. The permanent record thus obtained requires deciphering, an end which is obtained by the other portion of the instrument. This consists of a similar diaphragm held in a tube on the opposite side of the cylinder, attached to another point pressed against the tracing by a delicate spring. The original vibrations are thus transferred to a second membrane, and reproduced in the form of sound. The machine has been exhibited before several London Scientific Societies with complete success. Mr. Preece brought it under the notice of the Physical Society on March 2. Two forms of the instrument were illustrated. In one, the receiving and emitting disks are distinct, one being of ferrotype iron, and the other of paper; in the other, both functions are performed by one and the same disk of iron. In one, moreover, the drum is moved by hand; in the other by a train of wheels and a descending weight, regulated by an adjustable pair of vanes. Sounds emitted by the paper disk appeared to be more distinct than those from the iron. Professor Fleeming Jenkin suggests that the Phonograph may be found of value in throwing light upon the nature of vowel-sounds, and confirming or correcting Helmholtz's theory. A full detail of experiments made by him and Mr. Ewing on the subject is promised.

Ice as an Electrolyte.—Messrs. Ayrton and Perry have forwarded to the Physical Society a second communication on Ice as an Electrolyte. In their former paper they described experiments proving that as the temperature of ice is allowed gradually to rise, the conductivity increases regularly, and that there is no sudden change in passing from the solid to the liquid state. They also roughly determined the specific inductive capacity of ice and water at $-13°{\cdot}5$ and $+8°{\cdot}7$ Cent., showing that at the latter temperature it is 2,240 times as great as at the former; there being very little change in the capacity up to 0° Cent., nor after that point; it was expected that a very great change must occur at the melting point. In their second paper approximate curves have been traced from $-12°{\cdot}2$ to $+5°$ Cent. by charging for 10 seconds, and then short-circuiting for 15 seconds. The change at the melting point, though quite as sudden as expected, on the whole realizes their anticipations. "The important theory," they remark, "which Professor Clerk Maxwell has developed, by comparing the propagation of electro-magnetic disturbances through the ether with the propagation of light-vibration, has been illustrated only by paraffin, a non-conductor; and he has not considered the propagation of electro-magnetic disturbances in a conducting medium. But according to a former paper on the "Viscosity of Dielectrics," no dielectric can be affirmed to be non-conducting, and the charging of any condenser whatever is always accompanied by absorption

phenomena; also absorption certainly increases with conductivity. Hence, although, if a method of experimenting were employed in which a water-condenser of great internal resistance were discharged through wires of less resistance for shorter and shorter periods of time, the measured specific inductive capacity might get less and less, and gradually approach a value equal to the square of the index of refraction of water for infinitely long luminous waves (the index of refraction for air being called unity); still, practically, the measured specific inductive capacity can never be even approximately equal to the refractive index of water, since the absorbed charge is immeasurably greater than the surface-charge." We therefore need not expect to find the specific inductive capacity of water in its variations with temperature consistent with Dr. Gladstone's results for index of refraction.

New Form of Battery.—M. P. Jablockkoff describes to the Académie des Sciences a pile in which the attackable electrode is of coke. This substance not being attacked by any liquid at ordinary temperatures, heat was needed, and a substance which would only become liquid at a sufficiently elevated temperature, and be converted into vapour only at a still higher.

He fused nitrate of potass or of soda, and immersed in it as the attackable electrode ordinary coke, with platinum as the unattackable. For the latter, however, iron answers equally well. The electromotive force of this battery varies between two and three units. It is, therefore, superior to that of Bunsen or Grenet, the former of which gives 1·8 unit, the latter 2·0, or at best 2·1 units.

Previous fusion of the nitrate is not necessary. It is sufficient to ignite a piece of coke, and place it in contact with the powdered salt. The heat produced fuses the salt, and action begins. The action is not at all rapid. Much carbonic acid and other gas is liberated, and is stored up to act as a motive power.

Incrustation in Boilers.—The value of zinc in this capacity is now fairly established; and is probably due to galvanic action. Facts have been collected by M. Brossard de Corbigny; and M. Lesueur has stated the case of a steamer repaired in 1861 at Havre. It had three boilers, one of which, fed direct from the sea, was almost wholly oxidized and useless, while the others, which were fed with water from the condenser, were in perfect preservation. The condenser showed that the brass partitions were reduced to a comparatively pure spongy copper, the zinc having disappeared entirely. It was concluded that zinc could be made to act as a scale-preventer. In 1876 M. de Corbigny was requested to examine closely all the evidence, and to report to the Ministry of Public Works. The application of the zinc was generally in the simplest form, it being placed in a part of the boiler removed from the furnace. It was found that, with fair water, containing but little calcareous matter, the deposits, instead of forming adherent scale, were in the state of fluid mud, and easily removed by washing. If, however, the feed-water was strongly calcareous, the deposits were coherent and strong, but did not adhere to the iron, being easily removed by the hand, assisted by a scraper. The zinc was in time found to be reduced to a white earthy-looking oxide, consisting of 87·30 per cent. of this substance, with 3·80 of oxide of iron and aluminium, and 6·20 of lime carbonate.

No zinc was found in water drawn from the boilers. The opinion stated was that a small but continuous disengagement of hydrogen is maintained over the whole surface of the iron in contact with the water, the bubbles forming a film which separates the metallic surface from the scale-forming substance. —*Engl. Mechan.* March 3.

Currents of High Tension.—M. Planté employs secondary batteries of high tension made of plates of lead which constitute powerful accumulators of Voltaic electricity. By associating a number of batteries containing from 400 to 800 of these couples, a discharge is obtained equal to from 600 to 1,000 Bunsen batteries arranged for tension. All are arranged in simple circuit, and can be charged in a few hours by some Grove's or Bunsen's cells. By turning commutators all can be united in tension, and the enormous quantity of electricity thus accumulated made use of in a few seconds. If two copper wires be inserted in water, contained in a flat glass cell, acidulated with $\frac{1}{10}$th of sulphuric acid, and connected with such a secondary battery, or even with 15 or 20 Bunsen's batteries, a thick cloud of protoxide of copper issues from the end of the positive wire. If a strong magnetic pole be brought into the neighbourhood the cloud assumes a spiral form, of which the component rays turn in a left or right-handed direction, according as the pole is north or south.

ZOOLOGY.

On Lingula.—Professor E. S. Morse has communicated to the Boston Society of Natural History the results of an investigation of the structure and habits of *Lingula*, which he made on the coast of Japan. In a species of this curious and interesting genus of Brachiopods he discovered auditory capsules, resembling in position and general appearance the corresponding organs described and figured by Claparède in certain tubicolous annelids. The circulation in *Lingula* he maintains to be due entirely to ciliary action, and he altogether denies the presence of anything like a pulsatory organ. With regard to the habits of *Lingula* he states that when it is partially buried in the sand the anterior margins of the pallial membranes contract in such a way as to leave three large oval openings, one in the centre and one on each side. The long bristles of this region are then arranged in such a way as to form funnels leading directly to the openings, and these funnels acquire firm walls by the accumulation upon the bristles of the mucus flowing from the animal. A constant current is seen passing down the side funnels and up the central one. The *Lingulæ* bury themselves very readily in the sand, and the peduncle agglutinates a sand tube, by means of which, when in confinement, they attach themselves to the surface of the vessels.—*Silliman's Journal*, February 1878.

Solid-hoofed Deer and Pigs.—In our notice of the "Bulletin of the United States Geological and Geographical Survey of the Territories," we have mentioned that Dr. Coues has described the occurrence of a solidungulate condition in the Virginian deer, and in a peculiar Texan breed of pigs. Of the case of the deer, though not uninteresting, little need be said; the consolidation having been apparently observed only in a single specimen, and being confined to the horny hoof itself, the bones of the foot retaining their

normal character. In the pigs, on the other hand, the terminal phalanges of the toes have become united in the middle line, producing a single broad terminal phalanx, above which, however, the other phalanges of the toes remain perfectly distinct. Dr. Coues says, "The upshot of this modification of the foot is that a strictly artiodactyle animal is transformed into an imperfect perissodactyle one;" and from the characters presented by the terminal phalanx, even in a young animal, he is of opinion that its condition is "not the result of progressive confluence of the two bones, but of their original connation." The horny hoof encases the bones as far as the distal extremities of the proximal phalanges, and is perfectly solid, although in front there is a slight vertical line indicating the limits of the two halves. On the sole of the hoof there is a broad, angular elevation of horny substance, apex forward, and shaped so as to be curiously like the frog of the horse's hoof.

The occurrence of solid hoofs in the pig, as of cleft hoofs in horses and asses, has already been observed occasionally, but in the case of these pigs a regular solidungulate breed appears to have been established, and so firmly that no tendency to revert to the original form is observed in them. Mr. Marnock, of Helotes, Bexar County, who has furnished Dr. Coues with information and specimens, states "that the cross of a solid-hoofed boar with a sow of the ordinary type produces a litter the majority of which show the peculiarity of the male parent."

A New Chimæra.—Mr. T. Gill has announced his recognition of a new American species of the curious genus *Chimæra*, which he proposes to name *C. plumbea*. It is of a uniform lead colour, with the snout acutely produced, the anteorbital flexure of the suborbital line extending a little above the level of the inferior border of the orbit, the dorsals close together, the dorsal spine rounded in front, the ventrals triangular and pointed, and the pectorals reaching the outer axil of the ventrals. The only known specimen of this fish, which is a most interesting addition to the Atlantic fauna, was taken south-east of the La Have bank, at a depth of 350 fathoms, with a bait of halibut.—*Silliman's Journal*, March 1878.

The Mosquito an Intermediate Bearer of Human Parasites.—On the 12th of January it was first publicly announced that the female mosquito had been found capable of sucking up the young of *Filaria sanguinis hominis* (*F. Bancrofti*, Cobbold) when feeding on persons whose blood happened to contain these parasites (hæmatozoa). The discovery, for as such we must now regard it, was due to Dr. Patrick Manson, who acts as physician to the Missionary Hospital at Amoy, China. So far back as the year 1866, the late Dr. Wücherer detected a little nematode worm in the urine of a patient. He was at the time in search of the hæmatozoon known as *Bilharzia hæmatobia*. Curiously enough, he did not find the Bilharzia; nevertheless, only a few years later (1872) Dr. Cobbold, when engaged in examining the urine of a little girl from Natal, who passed thousands of Bilharzia eggs daily, encountered the embryonic nematode worm that Wücherer had been the first to observe. About the same time Dr. Lewis also detected the worm in a chylurous patient, and later on he made the remarkable discovery that the same microscopic nematode infested human blood. A few years afterwards Dr. Bancroft not only discovered the hæmatozoon, as such, in Australia, but on December 21, 1876, he made the important discovery of

he existence of the same entozoon in the sexually mature state. This worm was first described by Dr. Cobbold in the "Lancet" for October 6, 1877, and named after its discoverer. As regards the immature worm many similar finds were at different times made in various countries, by Drs. Salisbury, Sonsino, Crevaux and Corré, Foncervine, O'Neill, Silva Araujo, Da Silva Lima, F. dos Santos, and others; moreover, Dr. Lewis himself, only a few months later than Bancroft, verified the fact of the occurrence of the mature worm in the human body. Drs. Araujo and dos Santos have also found the full-grown worm. If the early announcements were received with incredulity, there does not seem much room left for doubt now. On March 7 Dr. Manson's investigations were brought before the Linnean Society with ample illustration and considerable minuteness of detail. From the remarks made after the reading of Manson's paper, followed as it was by a lengthened memoir on the part of Dr. Cobbold, reviewing the whole of the known facts as recorded by himself and some twenty other different observers, there seemed to be no escape from the conclusion that mosquitoes were true intermediate hosts, whose express duty it was to carry or nurse (as Manson says) the larvæ of the human nematode called *Filaria Bancrofti*. Further, it appeared that this entozoon was not only associated with, but the actual cause of several endemic affections, such as chyluria, hematuria, lymphoid diseases, elephantiasis, varix, and so forth. Professor Allen Thomson thought that the authors had fairly proved their case; and Sir Joseph Fayrer stated that he regarded the subject as one of unparalleled interest. In the course of the discussion Mr. McLachlan suggested the possible influence of fishes as intermediary bearers, whilst Mr. Curling, Dr. Collingwood and others testified from personal knowledge as to the conscientious character of Dr. Manson's work.

Hungarian Saltwater Rhizopods. — The third part of the Hungarian "Naturhistorishe Hefte," for 1877, contains an interesting paper by Dr. Geza Entz, on the Rhizopoda obtained from a pool of salt water at Szamosfalva, near Klausenberg. The species obtained, which are fully described and figured, are:—*Pleurophrys helix*, sp. n., *Plectrophrys prolifera* g. et sp. n. (allied to *Plagiophrys*, *Pleurophrys* and *Chlamydophrys*), *Euglypha pusilla* sp. n., *Microcometes tristrypetus* sp. n., *Orbulinella smaragdea*, g. et sp. n., *Ciliophrys infusionum*, Cienk., six species of *Amœba* (*guttula, limax, princeps, diffluens and radiosa*), and *Podostoma filigerum* Clap. and Lachm. Thus out of twelve species, five are described as new, and all of these are enclosed in capsules. From a previous investigation of the Infusoria of the salt ponds of Torda and Szamosfalva, the author arrived at the conclusion that while a portion of them had previously only been found in the sea, the greater part occurred both in salt and fresh water, but only a fourth part of the Infusoria obtained belonged to forms previously known only from the latter. With regard to the Rhizopods, the greater number are forms which are very abundant in fresh water, but are probably to be referred to the category of organisms common to both fresh and salt water; of the species peculiar to the salt pool, the closest allies of two (*Euglypha pusilla* and *Microcometes tristrypetus*) have hitherto only been found in fresh water, whilst the nearest relative of another (*Pleurophrys helix*) lives in sea water. Of the two new genera, one (*Orbulinella*) is related to the perforated marine Foraminifera,

and the other (*Plectrophrys*) to *Pleurophrys*. As a negative character, remarks that the *Arcellæ*, which are so abundant and so easily found fresh water, and the equally abundant and characteristic *Difflugiæ*, are wan ing in the salt pond just as in the sea.

Marine Amœbæ.—In the fourth part of the same periodical Dr. En notes the confirmation of his previous supposition that the *Amœbæ* observe in fresh water and in the salt pools, may also occur in the sea. In sea wat from Cuxhaven he found two *Amœbæ* (*A. limax* and *radiosa*) very abundantl He regards *A. marina*, Duj. and *A. polypodia*, Schulze, as probably identic with *A. radiosa*, and possibly also Häckel's *Protamœba polypodia*.

Young Limuli.—Mr. Alexzander Agassiz writes as follows to "Silliman Journal":—"Mr. C. D. Walcott has called attention to the fact that whe collecting fossils he finds large numbers of Trilobites on their back.* Fro this he argues that they died in their natural position, and that, when living they probably swam on their backs. He mentions, in support of his view the well-known fact that very young *Limulus*, and other crustacea, frequentl swim in that position. I have for several summers kept young horseshoe crabs in my jars, and have noticed that besides thus often swimming on their backs, they will remain in a similar position for hours, perfectly quiet on the bottom of the jars where they are kept. When they cast their skin it invariably keeps the same attitude on the bottom of the jar. It is not an uncommon thing to find on beaches, where *Limulus* is common, hundreds of skins thrown up and left dry by the tide, the greater part of which are turned on their backs. An additional point to be brought forward to show that the Trilobites probably passed the greater part of their life on their back, and died in that attitude, is that the young *Limulus* generally feed while turned on their backs; moving at an angle with the bottom, the hind extremity raised, they throw out their feet beyond the anterior edge of th cenopace, browsing, as it were, upon what they find in their road, a washing away what they do not need by means of a powerful current p duced by the abdominal appendages."—*Amer. Jour. Sci.*, January 1878.

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* "Ann. Lyc. Nat. Hist., N. Y.," Vol. XI., p. 155, 1875. "Twe eighth Report, N. Y. State Museum," Dec. 1876.

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TILDEN FOUNDATIONS

Fig. 1.

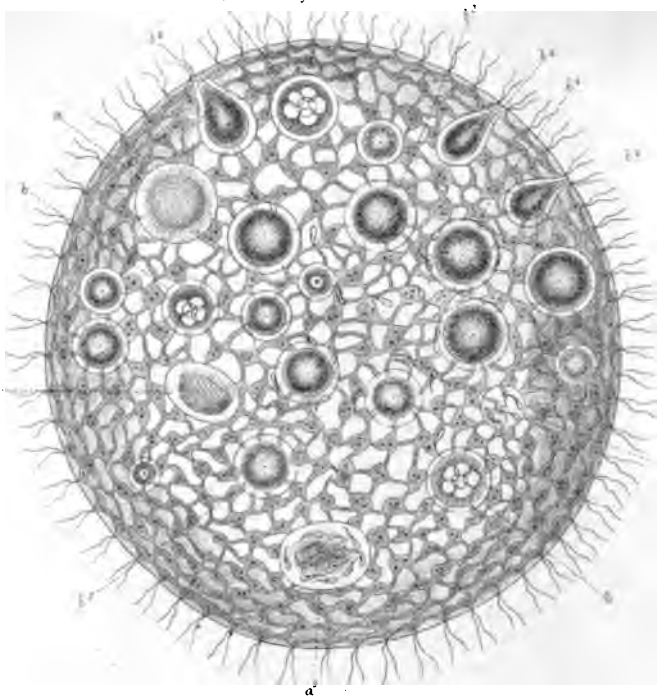


Fig. 2.

Fig. 3.

Fig. 4.

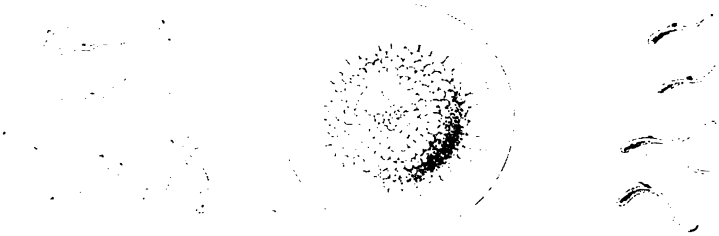
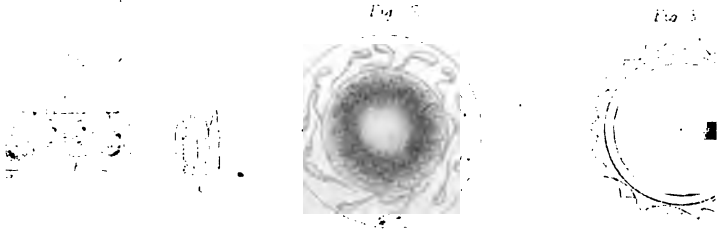


Fig. 5.



VOLVOX GLOBATOR.

By ALFRED W. BENNETT, M.A., B.Sc., F.L.S.
LECTURER ON BOTANY AT ST. THOMAS'S HOSPITAL.

[PLATE V.]

THE organism which we are about to describe has long been a favourite object for observation to microscopists, not only from the extraordinary beauty and delicacy of its structure, but from the remarkable phenomenon which it presents of a member of the vegetable kingdom endowed with a power of motion apparently as spontaneous as that possessed by any organisms belonging to the animal kingdom. The very location of the *Volvox* among plants has indeed been challenged. Like many others which are now placed, by almost universal consent, among the lower classes of Cryptogams, it was held by the distinguished naturalist Ehrenberg to be of animal nature. If, however, any doubt remained as to its true vegetable character, this has been completely set at rest by the researches of Professor Cohn,* who has only quite recently for the first time followed out completely the various stages of reproduction of this singular organism. In no English work will they at present be found adequately described, although so many observers had before his time had it under their notice.

The *Volvox globator* is not uncommon in clear pools on commons, and in similar situations, and is visible to the naked eye as a minute pale-green globule rolling through the water, passing rapidly across the field of view under the microscope, its full diameter being perhaps $\frac{1}{50}$ of an inch. Under the microscope it is seen that the rotatory motion is caused by innumerable fine transparent vibratile cilia, with which the surface is studded. The appearance presented by the entire body is that of a globular transparent, hollow, membranous sac, through which these cilia protrude, and studded with bright green points, while in the interior are seen a small number of dense green globes. In the autumn or early winter these internal globes have often

* "Beiträge zur Biologie der Pflanzen," Vol. i. Heft 3, 1875.

assumed an orange colour, giving to the whole globule a red tinge. The vibratile cilia already described are arranged in pairs, each pair belonging to a separate peripheral corpuscle or cell. These peripheral cells contain each a green protoplasm-body, varying in shape according to the age of the individual, as shown in fig. 2, *a*, *b*; they usually contain a minute starch-granule, a reddish-brown "eye-spot," analogous to that of swarm-cells (zoospores) and of the Flagellate Infusoria, and one or two contractile vacuoles, the cilia being borne at the narrow hyaline end. Each is surrounded by a gelatinous envelope, which is pierced by a number of canals, all lying nearly in one plane, and filled by green or colourless extensions of the protoplasmic interior. Since the canals of adjoining cells correspond, the corpuscles appear as if connected together by a network of fine reticulations. The outer gelatinous wall of each cell is also perforated by two pores, through which the two vibratile cilia protrude into the surrounding water. They constitute a single peripheral layer enveloping the entire organism, corresponding to the plate which is characteristic of many Chroococcaceæ; each one by itself would be undistinguishable from an ordinary swarm-cell of many filamentous Algæ, or from the entire individual of *Chlamydococcus* or *Pleurococcus* in its motile stage. They have, however, so far as is known, no reproductive function, and in this respect stand almost alone among cells endowed with a spontaneous power of motion.

Besides these non-reproductive or sterile cells, there are in each *Volvox*-colony three kinds of reproductive cells—non-sexual (neuter), male, and female. The neuter reproductive cells, or parthenogonidia, as Cohn terms them, are similar in structure to the sterile cells, but two or three times their size, i.e. from ·006 to ·009 mm. in diameter. Very early in the development of the young colony, they begin to multiply by bipartition, and all the cells in the same colony or sphere are usually at one time in the same stage of development. This division has been followed by Cohn through four stages, as shown in fig. 3, *a*–*d*, the fourth stage consisting of sixteen cells, beyond which he was unable to trace it, owing to the difficulty of the observation. At this stage it is described as having somewhat the form of a blackberry, each segment possessing a single chlorophyll-granule containing starch. The young colony is surrounded by a transparent membrane, which it at length breaks through, and carries on an independent existence within the cavity of the mother-colony, each of its cells developing a pair of cilia; finally it escapes from its confinement in the mother-colony into the surrounding water. The normal number of parthenogonidia which thus develope into colonies within the mother-colony is *eight*, corresponding to the eight cells into which each of them

breaks up on its third segmentation. The young colonies complete their growth in a few days, attaining a diameter of from 00·10 to 00·15 mm., and have by this time absorbed the greater part of the chlorophyll and starch of the mother-colony.

The sexual reproductive cells, male and female, are very few in proportion to the sterile cells. While the non-sexual reproduction by parthenogonidia takes place during the whole year, the sexual cells are apparently formed only in the autumn. The two kinds are found either in the same or in different colonies, establishing the classification of the genus into monœcious and diœcious sub-species, as first pointed out by Cohn. Fig. 1 represents a monœcious colony. The two modes of reproduction do not take place simultaneously in the same colony, the sexual generation forming the close of a longer or shorter series of non-sexual generations. *Volvox* presents, in fact, one of the earliest instances in the ascending series of the phenomenon known as alternation of generations, which attains its highest development in plants in the Vascular Cryptogams. The female cells (gynogonidia of Cohn) are at first undistinguishable from the parthenogonidia, but are much more numerous. On their first appearance they are about three times the size of the sterile cells; their protoplasm-body increases rapidly, and becomes of a dark green colour from abundance of chlorophyll. They have at first a frothy appearance (fig. 1, *b*) from the formation of vacuoles, but afterwards appear to be filled with protoplasm; and they are now at once distinguishable from the parthenogonidia by their never dividing. They soon become flask-shaped (fig. 1, b^2), their narrow end touching the periphery of the sphere, and the larger end hanging free into the cavity. When ready for impregnation they round themselves off into a spherical form (fig. 1, b^3), and may then be designated oospheres, each being enveloped in a gelatinous membrane or oogonium. The male cells, or androgonidia, present at first a still closer resemblance to the parthenogonidia, since, when they have attained about three times the size of the sterile cells, they begin to divide; but they are of a lighter colour, from containing a smaller quantity of chlorophyll. The divisions also take place only in two instead of in three directions, thus developing, not into a sphere, but into a plate of cells. They ultimately resolve themselves into a bundle of naked primordial cells (fig. 1, *a*), each consisting of a thicker but elongated body, in which the chlorophyll has been transformed into a reddish yellow pigment, and of a long colourless beak, to the base of which are attached two very long vibratile cilia, and where also is a red corpuscle or eye-spot (see figs. 4, 5, 6). The whole androgonidium may now be considered as an antheridium enclosed in a gelatinous envelope, each of the naked protoplasmic bodies being a motile antherozoid or spermatozoid. About the same

time that the gynogonidia have matured into oogonia, and their protoplasmic contents into oospheres, the movements of the vibratile cilia attached to the antherozoids begin to set the whole antheridium in motion, in the positions indicated in fig. 1, *a*, *a*^{2}; the antheridium soon breaks up, and the separate antherozoids are seen in rapid independent motion within the gelatinous envelope of the antheridium (fig. 1, *a*^{3}), which they ultimately break through, and then move about rapidly in all directions within the cavity of the mother-colony. Their movements are described by Cohn as being remarkably beautiful, the constant curvings of the elongated neck of the antherozoid being compared by him to those of the neck of a swan. They assemble in large numbers round the oogonia, and some of them finally penetrate through their gelatinous envelopes (fig. 1, *b*^{4}, fig. 7), and coalesce with their protoplasmic contents or oospheres. The fertilised oosphere is now an oospore, and developes a new cell-wall, the epispore, which is at first smooth, but afterwards covered with conical elevations, giving a section of it a stellate appearance (fig. 8). A second perfectly smooth membrane, the endospore, is subsequently formed within the first. The chlorophyll gradually disappears, and is replaced by an orange-red pigment dissolved in oil, so that the mature oospore, while still enclosed within the mother-colony, is of a bright red colour, giving the red tinge which *Volvox* often presents, even to the naked eye, at certain periods of the year. Individuals containing oospores still enveloped in their spiny coatings were described by Ehrenberg as a distinct species, under the name of *V. stellatus*. The number of sexual reproductive cells in a colony of *Volvox* varies greatly; Cohn has observed five or more male and about forty female cells.

Soon after the oospore reaches maturity, the mother-colony breaks up, single cells escaping from the combination and swimming about freely in the water; their further history is unknown; while the oospores fall to the bottom and there hibernate. Their further development has only been observed by Cienkowski, who states that the contents of each spore break up into eight spheres which ultimately swarm out.

Ehrenberg described two species of *Volvox*, *V. globator* and *V. stellatus*, both of which he considered to be infusorial animalcules. These have been determined by Cohn to be different stages of the same species, the former in its parthenogenetic, the latter in its sexually reproductive condition; Ehrenberg's *Sphærosira Volvox* is also another form of the same species. His *Volvox aureus*, and Stein's *V. minor*, are considered by Cohn to form a distinct sub-species of *V. globator*, differing from the typical form in the colonies being of a smaller size, and diœcious instead of monœcious, and in the epispore of the

oospore being smooth. The mode of fertilization of the latter form has not yet been directly observed. The genus is cosmopolitan, having been found throughout Europe, in North Africa, India, and North America.

The old family of Volvocineæ, which included the genera *Volvox*, *Eudorina*, *Pandorina*, *Gonium*, and *Stephanosphæra*, is placed by Sachs, in the 4th edition of his "Lehrbuch," under the Zygosporeæ, and in the section characterized by the conjugation of zoogonidia (swarm-spores or zoospores). It is evident, however, that the family, as so constituted, cannot be maintained, and Rostafinski's classification must be accepted as preferable, retaining those genera which exhibit the conjugation of swarm-spores as a family of Zygosporeæ under the name of Pandorineæ, while the true Volvocineæ are placed in the class of Oosporeæ,* in which the process of impregnation consists in the coalescence of one or more minute spontaneously motile antherozoids which escape from an antheridium, with a comparatively large oosphere contained in an oogonium. The process indeed bears a very close analogy to the mode of fertilization in one of the highest families of Oosporeæ, the Fucaceæ. The family Volvocineæ, as thus constituted, includes at present only the two genera *Volvox* and *Eudorina*. The structure and developmental history of the latter have been described by Carter.†

* This is the course followed in M'Nab's recent class-book of botanical classification.

† "Annals of Natural History," 3rd series, Vol. ii. 1858, p. 237.

EXPLANATION OF PLATE V.

Fig. 1. A monœcious colony of *Volvox globator*; *a*, a^2, a^3, antheridia; *b*, b^2, gynogonidia; b^3, b^4, oospheres.

Fig. 2. Ciliated peripheral cells.

Fig. 3. *a–e* Parthenogonidia in successive stages of division.

Fig. 4. Complete antheridium.

Figs. 5 and 6. Antherozoids.

Fig. 7. Oosphere containing antherozoids (see also fig. 1, b^4).

Fig. 8. Fertilized oosphere.

All the figures highly magnified.

ON SOME RECENT CONTRIBUTIONS TO THE THEORY OF THE MOTION OF THE MOON.

By E. NEISON, F.R.A.S.

A QUARTER of a century has now elapsed since the late Professor Hansen, of Seeberg, near Gotha, completed his elaborate researches on the motion of the moon, and he was enabled to announce that the lunar theory as developed by him fully represented the motion of the moon during the preceding century 1750–1850. Professor Hansen had then been at work on this recondite subject for nearly thirty years, and had won a high reputation, not only from the ingenious and powerful methods he had devised for attacking the most difficult problems of gravitational astronomy, but also from the entire mastery over the minutest details of the lunar theory which he had shown by his discovery of two inequalities of long period in the motion of the moon due to the attraction of the planet Venus. This announcement of Professor Hansen's coming from so high an authority was most gratifying to astronomers, for it showed that after one hundred years' work science had at last gained complete mastery over one of the most difficult problems of astronomy.

The discovery by Professor Hansen of the existence of these two terms of long period was a step of the greatest importance, for it appeared to completely remove the last great difficulty in the lunar theory, a difficulty which had been puzzling astronomers for many years; and it has been termed by Sir G. Airy "one of the greatest steps—perhaps the greatest step—in gravitational astronomy." For years it had been known that the moon was at times before, and at other times behind, the place in its orbit which it should have theoretically occupied. It had further been shown that this alternate retardation and acceleration was periodical in its character, and that it required about ninety years to proceed from one extreme to the other. This difference, moreover, was not unimportant, for at one time the moon would reach any fixed point in its orbit more than half a minute before its theoretical time, and at some other period it would be over half a minute later than the time fixed by theory. And what rendered this inequality the more perplexing to astronomers was the fact that they could not imagine any source from which it was even possible that there could arise such an

nequality. That it did not arise from the attraction of the un appeared to be certain from the investigations of Laplace, 'lana, Poisson, and Pontécoulant; that so large an inequality s this was due to the attraction of the planets seemed to be out f the question; and it did not appear possible that it could be ue to the attraction of the earth. It was left for Professor Iansen to discover its origin in an unlooked for source, namely, 1 the attraction of the planet Venus. He showed that this lanet, from its attraction on the earth and its satellite, pro- uced two terms of long period in the motion of the moon; by a ng and laborious calculation he computed the value of these erms; and he showed that the combined effect of these two erms of long period exactly accounted for that observed in- quality in the motion of the moon which had so long perplexed stronomers.

The first of the two new terms in the motion of the moon hich were discovered by Professor Hansen was principally due o the direct attraction of Venus upon the moon. From a emarkable numerical relation between the motion of the moon n its orbit and the motion of Venus and the earth around the un, for one hundred and forty years at a time the action of Venus on the moon tends to increase its distance from the earth nd so render its motion around the earth slower, whilst for the ext one hundred and forty years exactly the reverse action takes place. Thus from the direct attraction of Venus on the moon, ur satellite moves slower round the earth for one hundred and orty years, so that at the end of this period it is behind its mean place; and then for the next one hundred and forty years it moves quicker round the earth, and gets correspondingly before its mean place. This may be called the direct term of long period. The second term of long period discovered by Professor Hansen arises from the indirect action of Venus upon the moon. Sir G. Airy had discovered in 1828 that from the attraction of Venus upon the earth, this last body would alter- nately move in a rather larger or smaller orbit than it would have were it not for the attraction of Venus. He showed that for one hundred and twenty years the earth would be rather more distant from the sun, and for the next one hundred and twenty years, rather less distant from the sun, than would be otherwise the case. Professor Hansen now showed that this would cause a sensible variation in the motion of the moon. From the disturbing action exercised by the attraction of the sun, the moon cannot move round the earth so quickly as it would otherwise do. During then the term of one hundred and twenty years, when the earth had its distance from the sun in- creased from the attraction of Venus, the action of the sun decreased, and the moon is enabled to move more quickly rou

the earth, and at the end of the one hundred and twenty ye
has gained an appreciable amount, whilst for the one hundr
and twenty years when the earth is nearer the sun the reve
phenomenon takes place. This term may be called the indir
term of long period. The importance of these terms arises fr
their effects being cumulative for so many years, that althou
very small, at the end of the long period in which they act
one way they accumulate to something considerable.

It was generally considered by astronomers that Profes
Hansen had succeeded by this means in removing the
difficulty in the theory of the moon, and Sir John Hers
remarked in his address to the Royal Astronomical Soci
"that their discovery may be considered as a practical com
tion of the lunar theory, at least for the present astronom
age, and as establishing the entire dominion of the Newto
theory and its analytical applications over that refractory sa
lite." This view received full confirmation when it was fo
that Hansen's "Tables de la Lune," based on his investigat
accurately represented the motion of the moon. It appe
certain that the difficulties of the lunar theory were at
mastered.

Unfortunately this sanguine view has been found to be
mature; unexpected difficulties have sprung up in the l
theory, and Hansen's "Tables de la Lune," which so well re
sented the place of the moon during the interval 1750–1
have become seriously inaccurate, and are rapidly becon
more and more erroneous. It is certain, therefore, that the
still some serious deficiency in the theory of the moon w
formed the basis of Hansen's "Tables de la Lune." It is th
fore a matter of the greatest importance that the lunar th
should be rendered more perfect and the tables of the m
made more accurate. The practical importance of this i
great that it is probable that before long steps will be take
the authorities of both the American and English Nau
Almanacs to empirically correct the tables, so as to render
tabular places more accurate.

It is now generally known that Hansen, to make his t
represent the motion of the moon during the interval 1
1850, was obliged to give empirical values to the coefficien
the two terms of long period which he had discovered to be
duced by the action of Venus. Hansen considered he
justified in doing this by the circumstance that these empi
values enabled his tables to represent with accuracy the m
of the moon during the century prior to 1850, for it app
most improbable that the tables could represent the moti
the moon for a whole century and yet fail to continue to r
sent it. The tables, however, did not continue to represen

motion of the moon, and have been steadily deviating from the truth, until at the present time they show most serious and increasing errors. It is, therefore, certain that at least one, if not both of the empirical values which Hansen assigned to these two terms of long period must be erroneous. What then are the correct values, as Hansen's are wrong? Many of the recent contributions to the lunar theory have implicitly turned on this point.

The late M. Delaunay was the first to take up this subject, for he was unsatisfied with the manner in which Professor Hansen had dealt with these terms of long period. Delaunay had then been engaged for ten years on the theory of the moon, and he had devised an entirely original method of attacking the problem. This new method which he employed was most elegant and ingenious. Instead of attacking the problem all at once, he showed that it was possible to divide it into several hundred simpler problems, and to solve each of these separately. Each of the many hundred different perturbations to which the motion of the moon is subject was taken by itself and its influence separately calculated. By this means he had to deal with over a thousand simple operations, instead of two or three dozen much more complex operations. This new method is in practice very laborious, it is very liable to errors, and it requires much skill and experience in its use, but its analytical elegance and advantages won a high reputation for M. Delaunay. Moreover, in his skilled hands it proved a most successful means of attacking the problem, for he was enabled by its means to carry the lunar theory to a degree of perfection far beyond any of his predecessors.

Delaunay applied this method to the determination of the values of the two terms of long period which had been discovered by Hansen to be produced by the attraction of the planet Venus. He considered, first, the one which is due to the direct action of Venus on the moon; and in his calculations he neglected the effect of the small inclination of the orbit of Venus, because he considered that it would not be of any consequence. He found that this first term of long period would be very small, and he announced that Hansen's value was more than fifty times too large. He was induced, however, to re-examine his investigations, and, to render them somewhat more complete, he took into account the small inclination of the orbit of Venus. This new result he found very different from the previous, for it agreed closely with the value found by Hansen. The small inclination of the orbit of Venus which he had thought to be of no importance proved to be the very cause why the attraction of Venus was able to so much disturb the motion of the moon. The value for this term of long period which Delaunay had thus

calculated was found to agree well with the value empirically assigned to it by Hansen, so that this part of Hansen's tables was confirmed. It is true it differed from the complete theoretical value which Hansen had found for this term, but this was of slighter moment, for Hansen himself had expressed a strong doubt of its accuracy.

Delaunay proceeded next to the determination of the value of the second term of long period, namely, that which results from the indirect action of Venus. He calculated the value of this by the same method as before, but taking care to consider the effect of the inclination of the orbit of Venus, he announced that he made the value of this term less than one-hundredth of that assigned to it by Hansen. This was a most important matter, for if Delaunay was right in his conclusion, the tables of the moon calculated by Hansen must be seriously inaccurate, for without this term which Delaunay declared was so greatly in error, these tables would not represent the motion of the moon with any accuracy at all. At this period, however, the tables of the moon did represent its motion with considerable accuracy, which appeared to be a strong indication that Hansen was right, and not Delaunay. Moreover, it has been mentioned that Delaunay employed his new method of attacking the lunar theory in determining the value of these inequalities, and this rendered it difficult for those unfamiliar with it to follow his calculations. It was only when Hansen's tables of the moon were seen to be developing serious errors that general attention was turned to Delaunay's investigations.

Professor Newcomb, of Washington, was the next to take up the subject, which he in turn examined by a method of considerable novelty, but he has not published the details of his investigations. He was able, however, to completely confirm the results which had been arrived at by Delaunay. It appeared certain, therefore, that Hansen's tables were wrong. By this time, however, this last fact was unquestionable, for the tables were rapidly deviating from the real place of the moon, and it was obvious that there was some grave imperfection in Hansen's work.

In 1873 Sir G. Airy pointed out that the theoretical investigations of Delaunay and Newcomb appeared to render it certain that Hansen's second term of long period, namely, that mainly due to the indirect action of Venus, had no right to be present in his tables. He therefore directed his attention to determining whether it was possible after removing this term to make the tables represent the motion of the moon by suitably correcting certain of the elements of its orbit. Sir G. Airy found, however, that this was not possible. Even after applying the best possible corrections, there remained outstanding errors

of such magnitude that he felt convinced that there must still exist some serious defect in the lunar theory as developed in the theoretical basis of the tables.

Professor Newcomb has lately completed an elaborate investigation of the earlier observations of the moon. He takes for his data a number of eclipses of the moon, which are quoted by Ptolemy in his "Almagest," a still larger number which were observed by the Arabians during the ninth and tenth centuries, and a number of observations of eclipses and occultations which were made by different astronomers during the seventeenth and early part of the eighteenth centuries. The greater number of these last have remained unpublished since the time they were made, and were discovered by Professor Newcomb when examining the archives of the Paris observatory. These last constitute the basis of a most important contribution to astronomy, for by carefully reducing them Professor Newcomb has been enabled to deduce with considerable accuracy the observed place of the moon for epochs much anterior to 1750, where previously had terminated our exact observations of the moon. In fact, by means of this investigation of Professor Newcomb, astronomers can trace back the observed path of the moon with some exactitude to 1675, and with less certainty to 1620. Professor Newcomb has made use of the data furnished him by this investigation for the purpose of ascertaining how far the observed place of the moon agrees with Hansen's tables for the period anterior to 1750. He shows that they fail to do so, and that for epochs prior to 1750 Hansen's tables are as discordant with observation as they have proved to be for epochs subsequent to 1850. Assuming with the Astronomer Royal that one of Hansen's terms of long period ought to be rejected, Professor Newcomb then endeavours to ascertain what corrections must be introduced to make the tables best represent the observations. He shows that the mean motion of the moon must be decreased by nearly thirty seconds in a century, and the value of the secular acceleration of the mean motion be decreased by nearly one-third of the amount assigned to it by Hansen. Even, however, when the tables are thus corrected in the best possible manner, there remain such large outstanding errors that Professor Newcomb comes to the same conclusion as Sir G. Airy, that there is still some serious defect in the lunar theory.

Professor Newcomb draws attention to the fact that these outstanding errors can be entirely accounted for by supposing that the earth is subject to periodical inequalities in its rotation on its axis. For some years it had seemed to Professor Newcomb that this was the most probable hypothesis on which to explain these deviations between theory and observation. As he points out, it would be a most serious and unwelcome one, for, granting

its truth, it would be no longer possible to predict the apparent motion of the moon, since the changes in the rotation of the earth could not be expected to follow any determinate law. Further investigations have led Professor Newcomb to the gratifying conclusion that we may yet hope to find the source of these deviations in the effects of the attraction of some member of the solar system. Closer examination of the outstanding errors showed Professor Newcomb that they could be explained by a new periodical term with a period of about 260 years. This is very nearly the period of the term of long period which was discovered by Professor Hansen to be produced by the direct action of Venus on the moon. It occurred to Professor Newcomb that by slightly changing the constants in this term the outstanding errors might be reduced. The result was most striking. This term, like the other inequality in the motion of the moon, has for its argument a quantity proportional to the time added to a constant quantity; and Professor Newcomb found that merely by changing the sign of this constant part of the argument, all the considerable outstanding errors disappeared. It is, in fact, merely necessary to make this slight change, and Hansen's tables, when corrected as previously mentioned, well represent the motion of the moon from 1625 to 1875. This led Professor Newcomb to examine whether there was not some accidental mistake in the sign of this constant quantity, but he found that it was perfectly correct. It is, therefore, a mere chance that this change of sign of this quantity causes the outstanding errors to disappear in this way.

These investigations of Professor Newcomb very clearly establish the following conclusions. Firstly, that Hansen was entirely wrong in the value which he empirically assigned to one, at least, of the terms of long period in the motion of the moon, which arose from the attractions of Venus. Secondly, that if Delaunay's value of these terms be correct, there still remains to be discovered at least one more term of long period in the motion of the moon. Thirdly, that if both Hansen's tabular value and Delaunay's theoretical value be wrong, it is possible to satisfy the observations without supposing any new term to exist.

Quite recently another contribution has been made to this subject, which places the theory of these terms of long period in an entirely fresh light, and opens a means of reconciling the contradictory results obtained by two such distinguished astronomers as Hansen and Delaunay. Hansen never published an account of the manner in which he theoretically calculated the complete value of these terms of long period, but finding two results arrived at by different methods to be irreconcilable, he delayed publishing his investigations until he had completed

a third calculation. It is understood that this third investigation was never completed. It is well known, however, that Hansen would not admit the correctness of Delaunay's results, although he never stated his reasons for considering them to be imperfect. Little importance, however, seems to have been attached to Hansen's refusal to admit that Delaunay's researches invalidated his own, because it seemed natural to suppose that had Delaunay's investigations been imperfect, Hansen would have at once pointed this out. It has always seemed to me that Hansen must have had some very good reason for his objection to Delaunay's results, but that he was waiting until he had completed his third investigation of this difficult problem. Moreover it has already been mentioned that Delaunay employed his own peculiar method of attacking the problem, so that one who was not perfectly familiar with this new method would not readily follow the research. The last contribution to this subject opens the question—are Delaunay's investigations complete? This is a most important matter, for if Delaunay has omitted to take into consideration the whole of the problem, it is easy to see not only why there should be a difference between Hansen's and Delaunay's results, but why Hansen refused to admit the accuracy of Delaunay.

In his investigations Delaunay has very carefully calculated the effect of the attraction of Venus on the moon, and the effect of Venus upon the earth, and in this way indirect effect on the moon. The manner in which the planet thus produces inequalities in the motion of the moon has been already detailed. In these calculations Delaunay has carefully taken into consideration the fact that, owing to the difference in the attraction of the sun upon the moon and earth, the moon in its motion around the earth is affected by numerous inequalities. In all this work Delaunay's results are perfectly accurate. Beyond this Delaunay has not gone, and this really comprises the entire direct way in which Venus influences the motion of the moon. It has also been shown that from this action of the planet Venus for over a hundred years at a time, the moon moves in a very slightly larger orbit than it could were there no Venus to attract it, and that this is then followed by a similar period in which the moon moves in a proportionately smaller orbit. What Delaunay has not taken into consideration is the way in which the action of the sun upon the moon will be affected by this alternate enlargement and contraction of the orbit of the moon arising from the action of Venus. It is known that the slower the moon revolves around the earth, the more powerful is the disturbing action of the sun and the greater is the power it has of enlarging the orbit of the moon. During the period, therefore, when the attraction of the planet Venus

has enlarged the orbit of the moon, this body will move slower around the earth, the sun will have greater power over it and will be able to still further enlarge the orbit and cause the moon to revolve still slower around the earth. As this action will continue to accumulate for over one hundred years at a time, at the end of this period it may amount to a considerable retardation of the moon. From this effect of the attraction of the sun on the effect produced by the attraction of Venus, exactly similar inequalities will be produced to those arising from the action of the planet alone. From certain expressions on the part of Hansen it seems that he has not failed to take these circumstances into account, whilst Delaunay has entirely omitted to consider them in his investigations, so that his researches must be held to be imperfect. It is evident, therefore, that further research will be required to satisfactorily determine the value of these two terms of long period, and to decide whether Delaunay or Hansen is correct, or whether either is. And until this is done the theory of the terms of long period in the motion of the moon must be held to be in an unsatisfactory condition.

It is well known that the mean motion of the moon is at present slowly increasing, so that there is a gradual acceleration in the velocity with which it moves around the earth. This secular acceleration was discovered by Halley, a celebrated English astronomer, and for many years the greatest mathematicians were unable to discover its cause. In 1787, however, Laplace discovered that from the slow change in the eccentricity of the orbit of the earth, the mean motion of the moon would have a gradual secular acceleration, and on calculating what it would be, he found it would amount to rather over 10″ in a century. Now this was exactly the amount of the observed acceleration which had been discovered by Halley. Laplace's discovery appeared, therefore, to completely account for this observed acceleration of the velocity of the moon's revolution around the earth. Twenty-five years ago Professor Adams discovered that when the calculations were carried to a higher order of accuracy than had been considered necessary by Laplace, it very much reduced the value of the secular acceleration due to the decrease in the eccentricity of the orbit of the earth. At the time this discovery of Professor Adams gave rise to a very animated controversy, but it is now certain that the views of Professor Adams are perfectly correct, and that the secular acceleration in the mean motion of the moon which is due to the decrease in the eccentricity of the orbit of the earth, does not amount to more than 6·2″ in a century.

Professor Hansen, when he compared his tables with the ancient observations, found that they indicated a value of the

cular acceleration of 12·2″, or nearly double that which has ceived a theoretical explanation. This leaves a difference of ″ per century in the secular acceleration whose origin had to found. Newcomb and Delaunay both suggested that perhaps is difference between the observed and theoretical values of ie secular acceleration might be only apparent, and that the ifference might be due to a gradual increase in the length of ie day. It was pointed out that if the earth be supposed to e slowly retarded in its axial rotation, the day will be longer, nd as the moon will advance further in its orbit in the space of ne day, it will appear to have a secular acceleration. An increase in the length of the day of only one thousandth part of a econd in a century would amply account for the difference etween the theoretical and observed secular acceleration. It emained to be shown what would produce this retardation of he earth's axial rotation. Both Newcomb and Delaunay suggested that it might arise from the action of the tides, which, y their friction on the solid crust, might prove to be the origin f this decrease in the velocity of the rotation of the earth. Delaunay attempts to show, mathematically, that it was possible or the tides to produce this effect. It cannot, however, be said hat this attempt was successful.

This assumed retardation of the axial rotation of the earth nd its hypothetical origin in the friction of the tides of the cean against the earth, have been very generally accepted, and re very commonly employed for purposes of scientific argument, s if their truth had been rendered highly probable. It is, owever, important to remember that it has never yet been hown in a satisfactory manner that it is even possible for the ides to retard the rotation of the earth to a sensible extent. Moreover, as will now be shown, it is still most uncertain that here is really any retardation to be accounted for in this way. t must not be forgotten that the value found by Hansen presupposes that his tables are correct, but it has been seen already hat this is not the case. The late investigations of Professor Newcomb afford much valuable information on this subject.

It has been already mentioned that Professor Newcomb, hen correcting the data employed in Hansen's tables, found that he value of the secular acceleration which had been employed ught to be diminished by one-third. According to him the alue 8·4″ is that which best represents the observations, and hese observations are more trustworthy than any previously nade use of. Thus it is evident that the greater part of the upposed difference between the values of the theoretical and bserved secular inequality arises from the imperfect nature of he observations which hitherto have been made use of, together with the effect of the empirical term employed by Hansen to

bring his tables into accord with observation. In determining the correction to the secular acceleration employed by Hansen, it would appear that Professor Newcomb has attached considerable weight to the very earliest set of observations in his list. It is almost certain, however, that there is some serious imperfection in this set of observations, for they are entirely discordant with the remainder of the early observations, which are tolerably consistent with each other. As it is, Professor Newcomb has been unable to make the corrected tables represent this set of observations within nearly 16′, whilst it very materially interferes with the other observations. For this reason this earliest set of observations may have proportionately less weight attached to it.

Under these conditions it will be found that without materially interfering with the accuracy with which the modern observations (1625–1875) are represented, the ancient observations, including both the Arabian and the observations quoted by Ptolemy, can be much better represented by still further decreasing the value of the secular acceleration employed by Hansen. In fact, the value which best accords with the whole series of observations is 7·2″, or within 1″ of the theoretical value of the secular inequality. This reduces the supposed retardation of the rotation of the earth to a very slender foundation.

Professor Newcomb points out the very important fact that the more recent observations indicate a value for the secular acceleration much less than that indicated by the earlier ones. In fact, the Arabian observations are best represented by the theoretical value of the secular acceleration, which is 6·2″, while the ancient observations quoted by Ptolemy require the value 7·4″. This would seem to point to the existence of some periodical inequality. For some time it has appeared to me that the observations indicated the existence of a large term of very long period in the mean motion of the moon. This view is now confirmed by these investigations of Professor Newcomb. Such a term would require to have a period of over two thousand years to have a sensible effect on the secular acceleration. I have already shown that terms of this long period do exist in the mean motion of the moon. It remains to show that one of these terms has a coefficient of sufficient magnitude. Assuming the existence of such a term, and it can be shown that it would not only account for the difference between the values of the secular acceleration indicated by the modern and ancient observations, but it would remove the remaining difference between the observed and theoretical values of the secular acceleration. For this purpose the term would have to have a period of about 3,600 years, and a coefficient of under two minutes of arc.

Then correcting Hansen's terms of long period in the manner suggested by Professor Newcomb, diminishing Hansen's value of the mean motion by about forty seconds per century, and employing the theoretical value of the secular acceleration, the modified tables will completely represent the observations both ancient and modern. Indeed, by slightly altering the period of the term of long period, its coefficient might be much reduced, and it would still represent, with tolerable accuracy, the observations.

These considerations show that recent investigations go far to remove the supposed discrepancy between the value of the secular acceleration in the mean motion of the moon which is given by theory and by observation. They are sufficient to show that there is no necessity to assume any retardation in the rotation of the earth due to friction produced by the tides of the ocean.

In connection with the American expeditions for observing the transit of Venus, it became necessary to examine the corrections to Hansen's tables of the moon given by the observations made during the period 1862–1874. After applying various slight corrections to the differences between the observed and tabular places of the moon, Professor Newcomb was surprised to find systematic errors outstanding which could not be represented by corrections to the elements of the lunar orbit. At first he was inclined to attribute them to irregularities on the surface of the moon, but a more careful examination showed that they were periodic. Further investigation showed Professor Newcomb that they arose from small variation in the eccentricity and longitude of the perigee of the lunar orbit, this variation going through all its changes in a period of nearly seventeen years. Owing to these variations the moon would be periodically accelerated or retarded in its orbital motion by about three seconds of time. Professor Newcomb was unable to offer any explanation of the origin of these periodical variations. It has since been shown that they arise from the attraction of Jupiter on the moon in its revolution around the earth.

From the attraction of the sun upon the moon in its revolution around the earth, a great inequality is produced in the motion of the moon, from which its position in its orbit is alternately increased or decreased by nearly three hours. This great inequality was discovered by Ptolemy, and was subsequently named the *evection*. Every planet, by its attraction, produces a similar term, although much smaller; so much smaller, indeed, that it was generally thought that they would be too small to be ever detected. In general, this view is perfectly correct, and it would also be the case with Jupiter were

it not for the fact that Jupiter and the perigee of the lunar orbit have nearly the same period of revolution. Owing to this, the influence of Jupiter on the motion of the moon is very much augmented. It has also been discovered that Jupiter produced a still larger inequality in the motion of the moon, one twice as great as that discovered by Professor Newcomb, and having a period of more than seventeen years. This new inequality also derives its magnitude from the commensurability in the periods of revolution of Jupiter and the perigee of the lunar orbit, as from this reason the attraction of Jupiter continues to accumulate for nearly nine years at a time, amounting, at the end of this period, to an effect of appreciable magnitude.

A most able paper has been recently published by Mr. C. W. Hill, a mathematician connected with the American Nautical Almanac, in which he calculates the portion of the motion of the lunar perigee which is independent of the eccentricity and inclinations of the orbits of the sun and moon. The theoretical determination of the motion of the lunar perigee has always been a task of considerable difficulty, so that even the best strictly theoretical value of the period of revolution of the perigee around the lunar orbit differs from the observed value by about five minutes. This is a very considerable amount in the present advanced condition of the lunar theory, seeing that theory gives within a few seconds the same value as the observed period of the revolution of the line of nodes of the lunar orbit. Mr. Hill devised an entirely new method of determining the motion of the lunar perigee by skilfully utilizing some of the later developments in mathematical analysis. In this manner a very accurate value for the motion of the lunar perigee was obtained. In England, Professor Adams had independently arrived at the same method of solving this problem, and he had moreover determined the rate of motion of the line of nodes in the same manner. In these papers a most important contribution has been made to the lunar theory, for they open a means of determining the values of the inequalities in the motion of the moon which promises to be of great value. Its intricacy, and the great labour it involves, will probably however, restrict its use to special cases.

CLOUD OUTLINES.

Second Paper—Forms of Cumulus.

By Rev. SAMUEL BARBER, F.M.S.

In a former article in the *Popular Science Review*, attention was drawn to the importance of a close examination of the outlines of the various forms of cloud, and the instances selected for observation were the "electric cumulus," the "anvil" cloud, and the "festoon" cloud, these being among the most striking examples in respect to outline, and possessing at the same time considerable value as weather prognosticators. Unfortunately the illustrations which accompanied that article were accidentally omitted, and sketches are therefore appended to the present paper for future reference.

At the present time we propose to bring before our readers some other forms of cumulus of somewhat rarer occurrence, and for the most part attendant on unsettled weather.

In the first place, then, we call attention to a form which may be denominated "pyramid cumulus." Strictly speaking, it should be "inverted" pyramid cumulus, as the point or apex is generally *downwards* toward earth, or inclined at an angle with the horizon. The mass of the cloud, which is often very irregularly shaped at the larger end, partakes for the most part largely of the character of stratus or nimbus, and the surface is often marked by sinuous lines, which radiate from the apex upwards (fig. 1).

The cases in which I have observed this form of cloud have generally been during a thunderstorm, about its climax, or after the rain has begun to fall; one of the most striking instances, from which the illustration was taken, occurred during a storm which discharged itself about thirty miles from the point of observation, near Liverpool. Like the ordinary electric cumulus,* the pyramid cumulus sometimes rises to a great elevation, and is visible at a vast distance, when the lightning may be seen darting and playing about its surface; thus indi-

* *See* sketch, p. 247; and "Journal of Meteor. Soc." January 1872.

cating the violence of the storm over which it hovers, while the weather in the neighbourhood of the observer may be perfectly fine.*

This cloud derives interest from its evident connexion with that conical or funnel-shaped form of cumulus which attends the formation of a waterspout; and thus gives an indirect confirmation to the theory that this latter phenomenon is a result of electrical action. It seems quite evident that the

Fig. 1.

INVERTED PYRAMID CUMULUS.

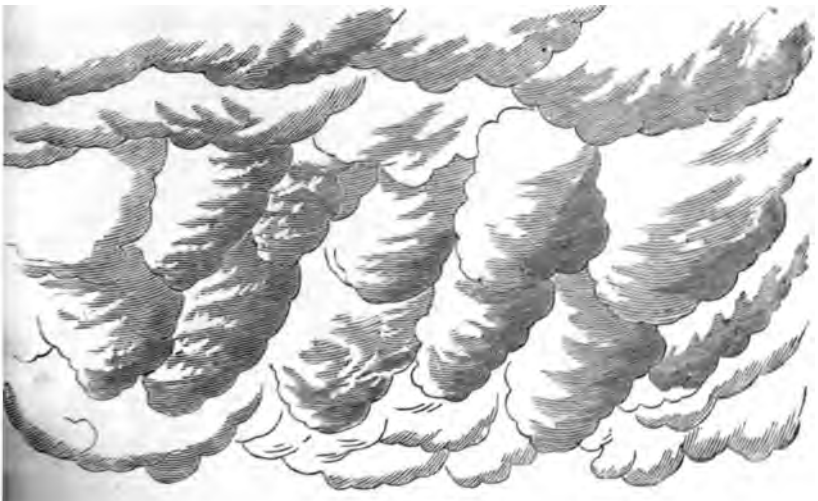
violent action, both on the water and on the atmosphere, which is exerted by a waterspout, and the tremendously rapid movement of the particles, can only result from the presence of a force acting with enormous power *at a limited distance.*

To afford a *raison d'être* for this phenomenon, and for that of the sand-pillar, from the ordinary mechanical laws regulating large masses of air, seems an obvious impossibility. But it may be objected that, if the pyramid cumulus and other cognate cloud forms are due to electric action of the air or vapour particles, how

* case of this kind occurred about the year 1869, and was described by e "Intellectual Observer."

does it happen that the surface of these clouds and their general contour do not change more rapidly? To this it may be replied, that if an observer were so placed as to obtain a distinct and near view of the *component particles* of the cloud, he might (and probably would) observe a *very rapid motion* among them. For, at a distance of several miles, appearances are very deceptive as to material composition,* movement of particles, &c.; and it is also plain that identity of *visible* form at two different moments is no proof whatever of an identity of the component particles, or (perhaps I should say) of a *continuity* of composition. Take, for example, the rainbow, which exhibits such exquisite symmetry and such apparent stability

Fig. 2.



FESTOON CLOUD.

of form as altogether to preclude the idea of change or motion, while it is well known that the bow and its colouring are due to refraction of light through a constant succession of falling drops, so that not only do two persons see different rainbows, but no one can see the same rainbow two moments together.

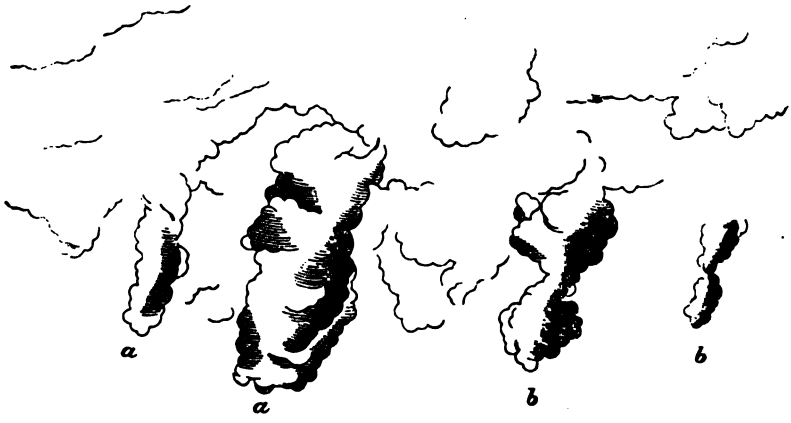
In the symmetrical marking which the pyramid cumulus assumes at times, we have a remarkable resemblance to that which is occasionally taken by the whirling sand-pillar of the desert, when the latter takes a compound form. A kind of complex

* A singular phenomenon may often be noticed in connection with the fall of rain, which has not been fully explained, viz.: the darting to and fro of small particles among the larger drops, like minute snowflakes flitting about in defiance of gravitation.

whirlwind is evidently the originating force, but whether the direction of the currents is originally upwards or downwards I must leave to other observers to determine. Perhaps we may find the true explanation of some of the more striking cloud forms in the action of two vapour currents of different densities meeting each other; but in the cases we have just considered, where a rapid motion is observed while the atmosphere all around is still, I think we may find a solution by applying the principle of correlation of forces, *i.e.* in the generation of electricity by heat or evaporation. The "festoon" cloud (fig. 2) which is commonly seen before squally weather and with a falling temperature, may, however, be due to ascending currents of vapour meeting colder currents of air descending towards the earth.

This may, perhaps, be also the origin of the next form of

Fig. 3.



DROPPING UMULUS.

a. Ordinary Forms. *b*. Accidental varieties in the shape of a dumb-bell.

cumulus which we take for examination, viz., the "dropping" cumulus (fig. 3). I am not aware that previous writers have considered this a distinct species; but it deserves to be so recognized for two reasons, viz., its value as a weather prophet (indicating wind and rain); and the curious inquiries which it suggests concerning the coherence of cloud masses, and the relation which the forces that determine this coherence bear to that of gravitation. A very ancient writer* has pointed out the scientific problems involved in this adjustment of mechanical laws, as yet far from solution.

There is a close affinity between this form and the "festoon"

* Book of Job, chap. xxxvii. v. 16.

cloud: the latter ought perhaps to be regarded as a variety of the "dropping" cumulus. The most curious characteristic of the cloud we are now considering is its manner of hanging down *endwise* towards the earth (fig. 3). It appears at times to have a hollow space within; for a kind of outward shell may be seen to form in the first instance, gradually developing from a vapoury strip or band, and rapidly assuming a semi-cylindrical shape (almost that of a bolster), and acquiring at last a full rotundity of outline. I have observed several masses formed in this way, parallel to each other, and all in different stages of development.

One day last autumn I saw several masses of this cloud (off Ramsgate), November 8. On the two following days there was a gale; the first being also very wet.

Among the accidental varieties of "dropping" cumulus, two curious forms may be noted: viz. that of a double cone and of a dumb-bell (fig. 3 *b*). The last-mentioned may be closely allied to the "anvil" cloud, but is looser in texture and generally more rapid in motion and change of form.

It has been remarked by some observers that the characteristics of the rarer clouds are very *local*, but it must be borne in mind that the same result will be observed where the *conditions* are the same. The varieties which we have just been considering have been seen by me in various parts of England, and I have taken notes for many years, chiefly in the neighbourhood of Liverpool and of Ipswich.

There seems to be a difference in the average altitude of clouds on the west and east coasts of England, those of the latter having the greater elevation. The estuaries of the Mersey and of the Dee present a very interesting field of observation; the varieties of cloud being numerous, the changes of form rapid, and the gradations of colouring and of light and shade rich and deep. To account for these phenomena we have: 1. The irregularity of the coast-line, with two considerable rivers lying close together; 2. The hills of North Wales; 3. The intermingling of currents, and the evaporation from the Gulf Stream. The part of East Kent—viz. that between Sandwich and Dover—in which I have lately made observations, presents finer effects in the rich glow of the upper sky, especially before sunrise and after sunset; a clear yet soft and rich golden light, into the depths of which the eye seems to penetrate, at times intensely beautiful. This glow was seen on several occasions in November last, 1877. The purity and depth of the ruby-tinted cirro-stratus at sunset is also very noticeable. The fine effects of cloud about Liverpool were, I believe, well known to Turner, who spent many a day making studies in the district. The excess of

vapour arising from flats and sandbanks gives a hazy and delicate effect to the light, very suggestive in a picture.

With regard to these differences of atmospheric effect caused by change of locality, it appears that such change is found rather in the grouping, elevation, and effects of light and colour, than in the forms themselves, though there are certain forms, no doubt, perfectly local, especially in mountainous districts. These generally owe their origin to geographical configuration; and their study lies as much within the province of the physical geographer as that of the meteorologist. In passing, however, I may remark that the curious disc or cap which is seen near the peak of some mountains, and which maintains its form in a breeze of wind, must have its particles in rapid motion; being caused by the continuous impact of vapour currents upon a colder stratum, which determines condensation and visibility. This is a good example of the principle stated above, that identity of visible form at two different moments is no proof of continuity of composition. The flame of a candle, which cannot, chemically, remain the same two moments together, affords another illustration of this. A cloud, like the human body, may often be likened to an eddy. Physiology teaches us that the body is sustained by a constant motion of particles drawn in from external sources and passed off again after undergoing a change of form; yet no one doubts his possessing the same body which he had, say, ten years ago. The saying, that "sameness" must not be confounded with "this-ness" and "that-ness," or *identity*, in its strictest sense, is applicable in both cases. Every cloud, as has been remarked by Espy, is either a forming or a dissolving one; but I think we may extend this, and say that some clouds are both "forming" and "dissolving" at the same time: e.g., cirro-cumulus forming from cirrus and melting into nimbus.

But we now pass on to consider a form of cumulus which is associated with very wet weather, and which I do not think has yet had a distinguishing title accorded to it. This I propose to call the "high-rain" cumulus. It is not a common species, and is mostly seen in autumn and spring. It deserves the name that I have given it, on account of the tremendously heavy showers that attend its appearance and the great elevation which it often attains. Unlike most forms of cumulus, which it is best to observe when somewhat near the horizon, so that the vertex may be seen in outline, this cloud reveals its characteristics best when almost overhead. Let the reader picture to himself a mild, muggy day in spring or autumn, everything soaking with recent showers, with heavy, lumpy-looking cumulus hanging about the horizon, and a drift of flattish, irregular cirro-cumulus

occupying *the upper stratum*.* Some of the masses of cumulus will be observed to throw off limbs or projections which swell out, and, ascending almost to the upper drift, seem to creep over the zenith much in the manner of a thunder-cloud when the electricity is gathering just over the place of observation. The cloud then forms into a kind of sheet (as seen from below) with rounded outline, and the edge broken with many small, curling indentations, somewhat like the leaves of several plants. The lower portion has a flat appearance, as if repelled, rather than attracted, by the earth. The elevation is considerable, and the tint of the cloud a dirty grey or slate-colour.

This kind of cloud frequently forms in enormous masses, as may be seen from its great altitude and the manner in which it spreads out towards the horizon; but, though much flatter in form than most varieties of cumulus, its surface is often broken or nodulous, like that of hail cumulus or electric cumulus when these are ready to discharge their contents. The peculiar form of the species we are considering is probably due in part to the saturated condition of the lower atmosphere at the time of its occurrence; and I have given to it the special designation of "rain" cumulus to indicate the excessively wet weather that it is generally associated with.

One of the most remarkable facts in connexion with atmospheric phenomena is this—that certain characteristic forms of cloud find their habitat within a certain zone, or at certain distances from the earth's surface. Taking the three main types (and omitting stratus), we find them usually in the following order, ascending from the earth: 1. Cumulus. 2. Cirro-cumulus, 3. Cirrus. The second of these appears to be an intermediate stage between cirrus, the ice-cloud in its normal state, and cumulus; or between cirrus and nimbus; and it has a very great range of altitude. Thus it might appear to be an exception to the law, that form depends partly on elevation; but it will, I think, be admitted that, as a general rule, it occupies a region lying between that of the other two species. But there are doubtless relations existing between the banks of cloud themselves which affect the question of form, as well as mere height above the earth. This especially would be the case where there was strong interchange of electrical action.

But whatever may be the *cause* of the fact we speak of, one thing in connexion with it deserves attention, viz., that any decided deviation from the law is significant of a disturbed condition of the atmosphere, and *may* be indicative of approaching storms. Let us take two cases to illustrate this: In very thundery weather, the two great types of cloud show a tendency

* See remarks below on the relative height of different species of cloud.

to interchange their places in regard to altitude; that is to say cumulus rises to an abnormal height, and cirrus descends to an unusually low position. This may generally be verified by watching the course of a thunderstorm; when the peaks of the first-mentioned cloud may often be observed, at a great distance, thrusting their pale yellow pinnacles into the azure of the heavens, long before the first muttering of the storm is heard, and while the mass of cloud is far beyond the horizon. On the other hand, when the hurly-burly is over and the rain has ceased, masses of nimbo-cirrus may at times be seen throwing up their silvery crests and curling over the earth like gigantic breakers. This last-mentioned appearance, which has a splendid effect, is, I believe, never seen except in thundery weather, or rather during electrical disturbance, and it is not easy to account for the existence of such forms by the action of wind. This remark applies also to what we may call "star" cirrus; that is, cirrus streaks radiating from a common centre in all directions (a form of cloud also connected with thunder-storms); and to that form which resembles the feathering of an arrow—parallel rays running from both sides of a common axis.

THE EXTINCT BRITISH WOLF.

By J. E. HARTING, F.L.S., F.Z.S.

(*Continued from* p. 154.)

Historical Evidence.—Scotland.

IN a preceding page it was incidentally remarked that the wolf survived in Scotland to a much later date than was the case in England. The reason is pretty obvious. Long after the animal had been extirpated in England the condition of the country in North Britain remained eminently suited to its nature. Vast tracts of forest and moor, rugged and well-nigh impenetrable in parts, entire districts of unreclaimed and uncultivated land, the absence of roads, and the consequent difficulty of communication between scattered and thinly populated hamlets, long contributed to shelter the wolf not only from final extinction but from the incessant persecution which had driven it from the south.

The aspect of the country in Scotland at the date to which we refer may be imagined from a remark of John Taylor, the Water Poet, who in 1618 travelled on foot from London to Edinburgh. When visiting Braemar, he says, "I was the space of twelve days before I saw either house, cornfield, or habitation of any creature, but deer, wild horses, wolves, and such like creatures, which made me doubt that I should never have seen a house again."

It must not be supposed, however, that the wolf at any time lived unmolested in Scotland. As the herdsman's foe, it was always regarded as a beast to be pursued and killed whenever and wherever practicable, and from the earliest times the chase of the wolf was considered by kings and nobles to be one of the most exciting and enjoyable of field-sports.

We learn from Holinshed that Dorvadil, the fourth king of the Scots, "set all his pleasure on hunting and keeping of houndes and greyhoundes, ordayning that every householder should find him two houndes and one greyhounde. If a hunter chanced in following the game to lose an eye or a limme, so that he were not able to helpe himselfe after that time, he made

a statute that he should be founde of the common treasury. He that killed a wolf should have an oxe for his paines. This beast, indeed, the Scottish men even from the beginning used to pursue in al they might devise, because the same is suche an enemie to cattayle, wherein consisted the chiefest portion of all their wealth and substance." *

Of a later king, Ederus, we are told that his "chiefe delighte was altogyther in hunting and keeping of houndes and greyhoundes, to chase and pursue wild beastes, and namely the woolfe the herdsman's foe, by means whereof his advancement was muche the more acceptable amongst the nobles, who in those dayes were whollye gyven to that kynde of pleasure and pastyme."†

Ferquhard II., who died A.D. 668, is said to have proved so bad a king that Colman, Bishop of Lindisfarne, declared the vengeance of God would overtake him. "And sure his wordes proved true: for within a moneth after, as the same Ferquhard followed in chase of a wolfe, the beast being enraged by pursuite of the houndes, flew back uppon the king, and snatching at him, did wounde and byte him righte sore in one of his sides, immediately whereupon, whether through anguishe of his hurt, or by some other occasion, he fell into a most filthie disease" (phthiriasis).‡

The sport enjoyed in Scotland in former days must have been incomparable. Bellenden, the translator of Hector Boece, says, that in the forests of Caledonia there were "gret plente of haris, hartis, hindis, dayis, rais, *wolffis*, wild hors, and toadis," (foxes), and he particularly mentions "the *wolffis*" as being "rycht noysum to the tame bestiall in all partis of Scotland."

In the reign of Malcolm IV. (1153–1165) Robert de Avenel granted to the monks of Melrose the right of pasturage in his lands in Eskdale, reserving to himself the privileges of the feudal baron, to pursue the wild boar, the deer, and the stag. One of his successors questioned several of the claims to which the grantees considered themselves entitled, and it was ultimately decided in 1235, in presence of King Alexander II., that they had no right to hunt over the lands in question, and were restricted from setting traps, *excepting for wolves*.§ It seems that, in order to protect their flocks, the monks of Melrose were in the habit of setting traps for wolves as early as the reign of William the Lion (1165-1214).‖ Wolfclyde, a part of the barony of Culter, in Lanarkshire, passed by grant to the Abbey of Melrose in 1431.¶

* Holinshed's Chronicles of Scotland, 1577, p. 13.
† Holinshed, tom. cit. p. 27. ‡ Holinshed, p. 148.
§ Morton's Monastic Annals of Teviotdale, pp. 273, 274.
‖ Chalmers' Caledonia, ii. p. 132. Chart. Mel. 91.
¶ Morton, op. cit. p. 276.

In a grant of Alexander II. (1214–1249) to the monks of Melrose, in Ettrick Forest, mention is made of "Wulfhope," a name still familiar in the south of Roxburghshire. *

In 1283, there was an allowance made for one hunter of wolves at Stirling. †

In 1427, in the reign of James I. of Scotland, an Act was passed for the destruction of wolves in that kingdom. Further Acts with the like object were passed in 1457, in 1525, and in 1577. The Act of 1525, however, is merely a modernized version of the law of 1427, which is referred to in the statute of 1577 as "the auld act made tharon."

The law required "that ilk baron within his barony in gangand time of the year sall chase and seek the quhelpes of wolves and gar slay them. And the baron sall give to the man that slays the woolfe in his barony and brings the baron the head, twa shillings. And when the baron ordains to hunt and chase the woolfe, the tenants sall rise with the baron. And that the barons hunt in their baronies and chase the woolfes four times a year, and als oft as onie woolfe beis seen within the barony. And that na man seek the woolfe with schott, but allanerly in the time of hunting them." The duty of summoning the people for a wolf-hunt devolved upon the "schireffs" or "bailyis," three times a year, between St. Mark's Day (April 25th) and Lammas (August 1st), for, as the Act states, "that is the tyme of their quhelpes." The penalty for disregarding this summons was "ane wedder," "quhatever he be that rysse not." On the other hand, it was enacted that whoever slew a wolf "sall haif of ilk householder of that parochin that the woolfe is slayne within, a penny."

The Act of James the Second's time (1457), provided that "they that slayis ane woolfe sall bring the head to the schireffe, baillie, or baronne, and he sall be debtour to the slayer for the summe foresaide. And quhatsumever hee bee that slayis ane woolfe, and bringis the head to the schireffe, lord, baillie or baronne, he sall have sex pennyes." ‡

In some active instances, the exertion of these statutes might have cleared local districts, and a remarkable example of success was given by a woman—Lady Margaret Lyon, Baroness to Hugh third Lord Lovat. This lady having been brought up in the low country, at a distance from the wolves, was probably the more affected by their neighbourhood, and caused them to be so vigorously pursued in the Aird, that they were exterminated

* Chalmers' Caledonia, ii. p. 132.

† Innes' "Scotland in the Middle Ages," p. 125.

‡ "Laws of the Parliament of Scotland," folio, 1781, pp. 18, 19. *See* also Glendook's Scots Acts, 7 James I. c. 104, and 14 James II. c. 88.

out of their principal hold in that range. According to the Wardlaw MS., "she was a stout bold woman, a great huntress; she would have travelled in our hills a-foot, and perhaps outwearied good footmen. She purged Mount Caplach of the wolves." Mount Caplach is the highest range of the Aird running parallel to the Beauly Frith, behind Moniach and Lentron. Though the place of the lady's seat is now forgotten, its existence is still remembered, and said to have been at a pass where she sat when the woods were driven for the wolves, not only to see them killed, but to shoot at them with her own arrows. The period of her repression of the wolves is indicated by the succession of her husband to the lordship of Lovat, which was in 1450, and it is therefore probable that the "purging" of Mount Caplach was begun soon after that date.*

Such partial expulsions, however, had little effect upon the general "herd" of wolves, which, fostered by the great Highland forests, increased at intervals to an alarming extent. During the reign of James IV. (1488-1513), rewards continued to be paid for the slaughter of wolves in Scotland, and we learn the value of a wolf's head in those days from the accounts of the Lord High Treasurer.† For instance, under date "October 24th, 1491," we find this entry:—

"Item, til a fallow brocht
ye king ij wolfis in Lythgow . . . Vs."

In the time of James V. their numbers and ravages were formidable. At that period great part of Ross, Inverness, almost the whole of Cromarty, and large tracts of Perth and Argyleshire, were covered with forests of pine, birch, and oak, the remains of which continued to our time in Braemar, Invercauld, Rothiemurchus, Arisaig, the banks of Loch Ness, Glen Strath-Farar, and Glen Garrie; and it is known from history and tradition that the braes of Moray, Nairn and Glen Urcha, the glens of Lochaber, and Loch Erroch, the moors of Rannach, and the hills of Ardgour were covered in the same manner.‡ All these clouds of forests were more or less frequented by wolves. Boethius mentions their numbers and devastation in his time,§ and in various districts where they last remained, the traditions of their haunts are still familiarly remembered. Loch Sloigh

* MS. History of the Frasers, in the library of Lord Lovat (p. 44). Also the curious account of the North Highlands called the Wardlaw MS. in the possession of Mr. Thompson, Inverness (p. 67).

† Extracts from these accounts will be found in Pitcairn's "Criminal Trials in Scotland," Vol. i. p. 116.

‡ MacFarlane's Geographical Collections. MS. Bibl. Facult. Jurid. ii. 92. Quoted in Smart's "Lays of the Deer Forest."

§ Scot. Hist. fol. 7.

and Strath Earn are still celebrated for their resort, and in 1848 there were living in Lochaber old people who related from their predecessors, that, when all the country from the Lochie to Loch Erroch was covered by a continuous pine forest, the eastern tracts upon the Blackwater and the wild wilderness stretching towards Rannach were so dense and infested by the rabid droves, that they were almost impassable.*

In 1528 the Earl of Athol entertained the king, James V., with a great hunt which lasted three days. "It is said, at this tyme, in Atholl and Stratherdaill boundis, thair was slaine threttie scoir of hart and hynd, with other small beasties, sich as roe and roebuck, *woulff*, fox, and wild cattis." †

A story is told of one John Eldar, a clergyman of Caithness, who journeyed on the death of James V. to England to present to Henry VIII. a project for the union of the two kingdoms. Being asked to explain the meaning of the name "redshanks," at that time given to the Highlanders, he said, "They call us in Scotland, 'redshanks,' please it your Majesty to understand, that we of all people can tolerate, suffer, and away best with cold: for both summer and winter (except when the frost is most vehement) going always bare-legged and bare-footed, our delight and pleasure is in hunting of red deer, *wolves*, foxes, and graies [badgers] whereof we abound and have great plenty. Therefore, in so much as we use and delight so to go always, the tender, delicate gentlemen of Scotland, call us 'redshanks.'" ‡

Harrison, who wrote in Elizabeth's time, says that though the English "may safelie boast of their securitie in respect to wild animals, yet cannot the Scots do the like in everie point within their kingdome, sith they have greevous woolfes and cruell foxes, beside some other of like disposition continuallie conversant among them, to the general hindrance of their husbandmen and no small damage unto the inhabiters of those quarters." §

William Barclay, who was a native of Aberdeenshire, and spent the early part of his life at the court of Queen Mary, accompanied her Majesty on an excursion to the Highlands, and has left a curious account ‖ of a royal hunt at which he was present, and which was organized for the Queen by John, fourth Earl of Athol, in 1563. Two thousand Highlanders were employed to drive all the deer from the woods and hills of

* Stuart's "Lays of the Deer Forest," Vol. ii. pp. 231, 232.

† Robert Lindsay, "Chronicles of Scotland," ii. p. 346.

‡ Pinkerton's "History of Scotland," ii. p. 396.

§ Harrison's "Description of England," prefixed to Holinshed's "Chronicle," i. p. 378.

‖ "De Regno et regali Potestate," &c., 4to, 1600, p. 279.

Athole, Badenach, Mar, Moray, and the surrounding country. After mentioning incidentally that the Queen ordered one of the fiercest dogs to be slipped at a wolf—"*Laxatus enim reginæ jussu, atque immissus in lupum, insignis admodum ac ferox canis*,"—Barclay concludes his account of the "drive" with the statement that there were killed that very day 360 deer, 5 wolves, and some roes.

According to Holinshed, wolves were very destructive to the flocks in Scotland during the reign of James VI. in 1577. At this time they were so numerous throughout the greater part of the Highlands, that in the winter it was necessary to provide houses, or "spittals" as they were termed, to afford lodgings for travellers who might be overtaken by night where there was no place of shelter. Hence the origin of the Spittal of Glen Shae, and similar appellations in other places.

Camden, whose "Britannia" was published in 1586, asserts that wolves at that date were common in many parts of Scotland, and particularly refers to Strathnavern.

"The county," he says, "hath little cause to brag of its fertility. By reason of the sharpness of the air it is very thinly inhabited, and thereupon extremely infested with the fiercest of wolves, which, to the great damage of the county, not only furiously set upon cattle, but even upon the owners themselves, to the manifest danger of their lives. In so much that not only in this, but in many other parts of Scotland, the sheriffs and respective inhabitants are bound by Act of Parliament, in their several sheriffdoms, to go a hunting thrice every year to destroy the wolves and their whelps." *

Bishop Lesley, writing towards the close of the sixteenth century, complains much of the prevalence of wolves at that period, and of their ferocity.†

"About this time there was nothing but the petty flock of sheep, or herd of a few milk-cows, grazed round the farm-house, and folded nightly for fear of the wolf, or more cunning depredators." ‡

Towards the end of the sixteenth and beginning of the seventeenth centuries large tracts of forests in the Highlands were purposely cut down or burned, as the only means of expelling the wolves which there abounded.

> "These hills and glens and wooded wilds can tell
> How many wolves and boars and deer then fell."
>
> *Campbell's* GRAMPIANS DESOLATE, p. 102.

* Camden, "Britannia," Vol. ii. p. 1279. The editor, Dr. Gibson, Bishop of Lincoln, has a marginal note to this passage "No wolves now in Scotland" (1772). Gough's edition, 1787, Vol. ii. p. 445.

† "De Origine, Moribus et Rebus Scotorum."

‡ Irvine's "Scotch Legal Antiquities," p. 264.

"On the south side of Beann Nevis, a large pine forest, which extended from the western braes of Lochaber to the Black Water and the mosses of Rannach, was burned to expel the wolves. In the neighbourhood of Loch Sloi, a tract of woods nearly twenty miles in extent was consumed for the same purpose." *

John Taylor, the Water Poet, who made his "Pennyles Pilgrimage" into Scotland in 1618, saw wolves in Braemar. He writes: "My good Lord of Mar having put me into shape, I rode with him from his house, where I saw the ruins of an old castle, called the castle of Kindroghit. It was built by King Malcolm Canmore (for a hunting house), who reigned in Scotland when Edward the Confessor, Harold, and Norman William reigned in England. I speak of it because it was the last house that I saw in those parts; for I was the space of twelve days after before I saw either house, cornfield, or habitation of any creature, but deer, wild horses, *wolves*, and such-like creatures, which made me doubt that I should never have seen a house again." †

Years later, as we learn from Sir Robert Gordon, the wolf was still included amongst the wild animals of Sutherlandshire. He says the forests and "schases" in that county were "verie profitable for feiding of bestiall, and delectable for hunting, being full of reid deer and roes, *woulffs*, foxes, wyld catts, brocks, skuyrells, whittrets, weasels, otters, martrixes, hares, and fumarts." ‡

In 1621 the price paid in Sutherlandshire for the killing of one wolf according to statute was 6*l*. 13*s*. 4*d*.

Wolf-skins are mentioned in 1661 in a Customs Roll of Charles II., § whence it appears that two ounces of silver were paid "for ilk two daker." ‖

Twenty years later, if we are to credit the statement of Sir Robert Sibbald, whose "Scotia Illustrata" was published in 1684,

* Notes to Sobieski Stuart's "Last Deer of Beann Doran." *See* his "Poems" published in 1822 under the assumed name of James Hay Allan.

† "The Pennyles Pilgrimage, or the Moneylesse Perambulation of John Taylor, alias the King's Majesties Water Poet. How he travailed on foot from London to Edenborough in Scotland. With his description of his entertainment in all places of his journey and a true report of the unmatchable hunting in the Brea of Marre and Badenoch in Scotland." 4to, London, 1681.

‡ "Genealogical History of the Earldom of Sutherland, from its origin to the year 1630."

§ *See* Glendook's "Scots Acts, Charles II.," p. 36.

‖ The word "daker" or "dicker" is still in use in the leather trade, and means a roll of ten skins. It was anciently spelt "dyker" or "dykker," and the market toll was a penny each "dyker."

the animal had become extinct. His words are: *Lupi olim frequentes erant, quidam etiam de Caledoniis ursis loquuntur. Sed horum genus deletum et ex insulâ exterminatum est.*" *

Pennant states that the wolf became extinct in Scotland in 1680, when the last of the race was slain by Sir Ewen Cameron of Lochiel. He adds that he had travelled "into almost every corner of that country, but could not learn that there remained even the memory of these animals among the oldest people." †

Surtees gives the date of the death of the last wolf in Scotland as 1682. ‡

From more recent investigation, however, it is clear that Sir Robert Sibbald and Pennant were both mistaken, for not only were wolves slain in Scotland subsequently to 1680, but numerous traditions concerning these animals survived in the country to at least as recent a date as 1848.

Tradition.—In a Gaelic forest lay "of a remote period, the date and author of which are uncertain," the wolf is thus referred to as inhabiting the ancient pine woods of Scotland:—

"Chì mì Sgòrr-eild' air bruaich a' ghlinn'
An goir a' chuthag gu-binn an dòs.
'Us gòrm mheall-àild' nam mìle guibhas
Nan *lùb*, nan earba, 's nan lon."

"I see the ridge of hinds, the steep of the sloping glen,
The wood of cuckoos at its foot,
The blue height of a thousand pines,
Of *wolves*, and roes, and elks."§

Other Gaelic names for the wolf are *madadh alluidh*, commonly used; *faol chu*, and *alla mhadadh*, all of which are composed of an epithet and a word which now means dog.‖ It is also called *faol* and *mac tire*, "earth's son." ¶

In Scrope's "Days of Deer-stalking" (p. 109) is related an adventure with a wolf that happened to Macpherson of Brakaely, when he had the charge of the Forest of Benalder, and was furnished to the author by Cluny Macpherson, chief of Clan-chattan.

* "Scotia Illustrata, sive Prodromus Historiæ Naturalis," folio, 16[illegible] pars ii. p. 9.

† "British Zoology," Vol. i. p. 88, and "Tour in Scotland," Vol. i. 206. *See* also Macaulay's "History of England," Vol. ii. p. 320.

‡ "History and Antiquities of the County of Durham," Vol. ii. p. 172.

§ From "The Aged Bard's Wish," given in Stuart's "Lays of the D[illegible] Forest," ii. p. 9.

‖ Pinkerton's "Enquiry into the Early History of Scotland," Vol. [illegible] p. 85.

¶ [illegible]pbell's "Tales of the West Highlands," Vol. i. p. 274.

"He sallied forth one morning, as he was wont, in quest of venison, accompanied by his servant. In the course of their travel, they found a wolf den—a wolf being at that time by no means a rarity in the forest. Macpherson asked his servant whether he would prefer going into the den to destroy the cubs, or remaining outside to guard against the approach of the old ones. The servant, preferring what appeared to be an uncertain to a certain danger, said he would remain without; but here Sandy had miscalculated, for, to his great dismay, the dam came raging to the mouth of the cave, which no sooner did he see than he took to his heels incontinently, without even warning his master of the danger. Macpherson, however, being an active, resolute man, and expert at his weapons, succeeded in killing the old wolf as well as the cubs."

This Macpherson of Braekaely was commonly called Callum Beg, or Little Malcolm; and there is reason to believe that he was one of those who fought in the famous battle of the Inch of Perth in the reign of Robert III. (1390–1406.)

In the districts where wolves last abounded, says Stuart in the "Lays of the Deer Forest," many traditions of their history and haunts have descended to our time. The greatest number preserved in one circle were in the neighbourhood of Strath Earn.

At Inver-Rua, on the Spean, and consequently within the lands of Keppach, there lived a Campbell of the Slioched Chailein Mhic-Dhonnacha, or Glen Urcha race. Although thus a tenant of one of the principal branches of the Clan Donald, and removed to the distance of forty miles from his *ceann tighe*, he continued to pay his "calps" to his blood chief, the Knight of Loch Awe. This tax was a heifer, which was paid annually, and it happened one year that a short time before it fell due, the beast was killed on her pasture and half eaten by a wolf. Campbell left what remained to tempt his return, and on the following night, watching the carcase, he shot the wolf from behind a stone. Not being able, however, to afford another "calp," he flayed the dead heifer, and sent the torn hide to MacChailein Mhic-Donnacha, with a message that it was all which he had to show for his "calp;" upon which the chief observed, that he had sent sufficient parchment to write his discharge.

This is said to have happened in the time of Sir Duncan Campbell, called "*Donacha dubh a' Currach'd*," "Black Duncan of the Hood," so called from having been the last person of his rank who wore the old Highland hood in Argyleshire, and who lived in the reign of James VI. (1567–1603.)

Several traditions relative to wolves are evidences of the accuracy with which oral relations have been transmitted through many generations, which is exemplified by the familiarity and

fidelity with which they retain allusions to objects and customs disused for two hundred years.

An example of this occurs in an account of the slaughter of a remarkable wolf killed by one of the lairds of Chisholm in Gleann Chon-fhiadh, or the Wolves' Glen, a noted retreat of these animals in the sixteenth century.

The animal in question had made her den in a "càrn," or pile of loose rocks, whence she made excursions in every direction until she became the terror of the country. At length the season of her cubs increasing her ferocity, and having killed some of the neighbouring people, she attracted the enterprise of the Laird of Chisholm and his brother, then two gallant young hunters, and they resolved to attempt her destruction. For this they set off alone from Strath Glass, and having tracked her to her den, discovered by her traces that she was abroad; but detecting the little pattering feet of the cubs in the sand about the mouth of the den, the elder crept into the chasm with his drawn dirk, and began the work of vengeance on the litter. While he was thus occupied, the wolf returned, and infuriated by the expiring yelps of her cubs, rushed at the entrance, regardless of the younger Chisholm, who made a stroke at her with his spear, but such was her velocity, that he missed her as she darted past, and broke the point of his weapon. His brother, however, met the animal as she entered, and being armed with the left-handed *lâmhainn-chruaidh*, or steel gauntlet, much used by the Highlanders and Irish, as the wolf rushed open-mouthed upon him, he thrust the iron fist into her jaws, and stabbed her in the breast with his dirk, while his brother, striking at her flank with the broken spear, after a desperate struggle she was drawn out dead.

The spear and the left-handed gauntlet referred to in this tradition are arms mentioned by Spencer, Leslie, and other authorities, as characteristic of the Highlanders and Irish in the days of Queen Mary.*

It is true they retained the use of such ancient weapons as late as their muster called the "Highland Host" in 1678.† But no such remains appeared at Cilliechranchie, and it is therefore probable that the story has descended from the time of Charles II.

Another story is on record of a wolf killed by a woman of Cre-lebhan, near Strui, on the north side of Strath Glass. She had gone to Strui a little before Christmas to borrow a girdle

* Cf. Spencer's "Views of Ireland;" Derrick's "Image of Ireland;" Leslie, "De Origine, Moribus et Rebus Scotorum;" and a print in the Douce Collection, Bodl. Lib. G. vi. 47.

† Wodrow MS. Bibl. Facult. Jurid. xcix. No. 29.

(a thick circular plate of iron, with an iron loop handle at one side for lifting, and used for baking bread). Having procured it, and being on her way home, she sat down upon an old càrn to rest and gossip with a neighbour, when suddenly a scraping of stones and rustling of dead leaves was heard, and the head of a wolf protruded from a crevice at her side. Instead of fleeing in alarm, however, "she dealt him such a blow on the skull with the full swing of her iron discus, that it brained him on the stone which served for his emerging head."

This tradition was probably one of the latest in the district, and seems to have belonged to a period when the wolves were near their end. Their last great outbreak in the time of Queen Mary led to more vigorous measures, which in the time of Charles II. reduced their ranks to so small a number that in some districts their extinction is believed to have followed soon after that period. Thus, in Lochaber, the last *in that part of the country* is said to have been killed by Sir Ewen Cameron in 1680, which Pennant misunderstood to have been the last of the species in Scotland.*

Some traditionary notices there are of the destruction of the last wolves seen in Sutherlandshire, consisting of four old ones and some whelps which were killed about the same time at three different places,—at Auchumore in Assynt, in Halladale, and in Glen Loth—widely distant from each other, and as late as between the years 1690 and 1700.

The death of the last wolf and her cubs on the eastern coast of Sutherlandshire, says Scrope, was attended with remarkable circumstances.

"A man named Polson, of Wester Helmsdale, accompanied by two lads, one of them his son and the other an active herdboy, tracked a wolf to a rocky mountain gully which forms the channel of the burn of Sledale in Glen Loth. Here he discovered a narrow fissure in the midst of large fragments of rock, which led apparently to a larger opening or cavern below, which the wolf might use as his den. The two lads contrived to squeeze themselves through the fissure to examine the interior, whilst Polson kept guard on the outside.

"The boys descended through the narrow passage into a small cavern, which was evidently a wolf's den, for the ground was covered with bones and horns of animals, feathers, and eggshells, and the dark space was somewhat enlivened by five or six active wolf cubs. Polson desired them to destroy these; and soon

* In the Sale Catalogue of the "London Museum" which was disposed of by auction in April 1818, there is the following entry: "Lot 832. Wolf —a noble animal in a large glass case. The last wolf killed in Scotland by Sir E. Cameron."

after he heard their feeble howling. Almost at the same time, to his great horror, he saw approaching him a full-grown wolf, evidently the dam, raging furiously at the cries of her young. As she attempted to leap down, at one bound Polson instinctively threw himself forward and succeeded in catching a firm hold of the animal's long and bushy tail, just as the forepart of her body was within the narrow entrance of the cavern. He had unluckily placed his gun against a rock when aiding the boys in their descent, and could not now reach it. Without apprising the lads below of their imminent peril, the stout hunter kept a firm grip of the wolf's tail, which he wound round his left arm, and although the maddened brute scrambled and twisted and strove with all her might to force herself down to the rescue of her cubs, Polson was just able with the exertion of all his strength to keep her from going forward. In the midst of this singular struggle, which passed in silence, his son within the cave, finding the light excluded from above, asked in Gaelic, 'Father, what is keeping the light from us?' 'If the root of the tail breaks,' replied he, 'you will soon know that.' Before long, however, the man contrived to get hold of his hunting knife, and stabbed the wolf in the most vital parts he could reach. The enraged animal now attempted to turn and face her foe, but the hole was too narrow to allow of this; and when Polson saw his danger he squeezed her forward, keeping her jammed in, whilst he repeated his stabs as rapidly as he could, until the animal being mortally wounded, was easily dragged back and finished.

"These were the last wolves killed in Sutherland, and the den was between Craig-Rhadich and Craig-Voakie, by the narrow Glen of Loth, a place replete with objects connected with traditionary legends."*

This story was related by the Duke of Sutherland's head forester in 1848 to Mr. J. F. Campbell, who has narrated it in his "Popular Tales of the West Highlands," Vol. i. p. 273.

"Every district," says Stuart in his "Lays of the Deer Forest," "has its 'last' wolf," and there were probably several which were later than that killed by Sir Ewen Cameron.† The "last" of Strath Glass was killed at Gusachan according to tradition "at no very distant period." The "last" in Glen Urchard on the east side of the valley between Loch Leiter and Sheugly, at a place called ever since *Slochd à mhadaidh*, *i.e.*, the wolf's den; and the last of the Findhorn and also (as there seems every reason to believe) the last of the species in Scot-

* Scrope's "Days of Deer Stalking," p. 374.

† A portrait of this devoted partisan of the House of Stuart was exhibited at the meeting of the British Association at Aberdeen in 1859.

land, at a place between Fi-Giuthas and Pall-à-chrocain, and according to popular chronology no longer ago than the year 1743. The district in which he was killed was well calculated to have given harbour to the last of a savage race. All the country round his haunt was an extent of wild and desolate moorland hills, beyond which, in the west, there was retreat to the vast wilderness of the Monaidh-liith, an immense tract of desert mountains utterly uninhabited, and unfrequented except by summer herds and herdsmen, but when the cattle had retired abundantly replenished with deer and other game, to give ample provision to the "wild dogs." The last of their race was killed by MacQueen of Pall-à-chrocain, who died in the year 1797, and was the most celebrated "carnach" of the Findhorn for an unknown period. Of gigantic stature, six feet seven inches in height, he was equally remarkable for his strength, courage, and celebrity as a deer-stalker, and had the best "long dogs" or deer greyhounds in the country. One winter's day, about the year before mentioned, he received a message from the Laird of MacIntosh that a large "black beast," supposed to be a wolf, had appeared in the glens, and the day before killed two children, who with their mother were crossing the hills from Calder, in consequence of which a "Tainchel" or "gathering" to drive the country was called to meet at a tryst above Fi-Giuthas, where MacQueen was invited to attend with his dogs. He informed himself of the place where the children had been killed, the last tracks of the wolf, and the conjectures of his haunt, and promised his assistance.

In the morning the "Tainchel" had long assembled, and MacIntosh waited with impatience, but MacQueen did not arrive. His dogs and himself were, however, auxiliaries too important to be left behind, and they continued to wait until the best of a hunter's morning was gone, when at last he appeared, and MacIntosh received him with an irritable expression of disappointment.

"*Ciod e a chabhag?*" ("What was the hurry?") said he of Pall-à-chrocain.

MacIntosh gave an indignant retort, and all present made some impatient reply.

MacQueen lifted his plaid and drew the black, bloody head of the wolf from under his arm!

"*Sin e dhùibh!*" ("There it is for you!") said he, and tossed it on the grass in the midst of the surprised circle.

MacIntosh expressed great joy and admiration, and gave him the land called Sean-achan for meat to his dogs.

Sir Thomas Dick Lauder, in his "Account of the Moray Floods of August, 1829," tells the story of the wolf killed in that district by MacQueen of Pall-à-chrocain, but lays the

scene of the exploit in the parish of Moy in the county of Inverness, which, although within the bounds of the ancient province of Moray, is far beyond the present limits of the forest of Tarnaway.

Sir Thomas gives the very words which MacQueen is said to have used in describing to the chief of MacIntosh how he killed the wolf: "As I came through the *slochk* (*i.e.* ravine) by east the hill there," said he, as if talking of some everyday occurrence, "I foregathered wi' the beast. My long dog there turned him. I buckled wi' him, and dirkit him, and syne whuttled his craig (*i.e.*, cut his throat), and brought awa' his countenance for fear he might come alive again, for they are very precarious creatures." In reward for his bravery, his chief is said to have bestowed on him a gift of the lands of Sean-a-chan "to yield meal for his good greyhound in all time coming." Sir Thomas Lauder has preserved another tradition of the extirpation of the wolf in Morayshire, when two old wolves and their cubs were killed by one man in a ravine under the Knock of Braemory, near the source of the Burn of Newton.

In the old "Statistical Account of Scotland," edited by Sir John Sinclair, and published in twenty-one volumes between the years 1791 and 1799, a few entries relating to the wolf occur, but they are neither numerous nor important. Mr. J. A. Harvie Brown, who has lately examined the entire series of volumes for another purpose, has obligingly communicated the following particulars: "The woods in Blair Athole and Strowan in Perthshire once afforded shelter for wolves (Vol. ii. p. 465), as did also the district around Cathcart in Renfrewshire (Vol. v. p. 347). In Orkney it appears they were unknown (Vol. vii. p. 546). The wilds and mountains of Glenorchay and Innishail in Argyleshire are noted as being formerly haunted by these animals, whence they issued to attack not only the flocks but their owners (Vol. viii. p. 343). Towards the west end of the parish of Birse in Aberdeenshire there is a place in the Grampians still known (1793) by the name of the Wolf-holm (Vol. ix. p. 108). Ubster, a town in Caithness (from 'Wolfster,' Danish or Icelandic) appears to have received its name either from its being of old a place infested with wolves, or from a person of the name of Wolf (Vol. x. p. 32). In Banffshire the last wolf is said to have been killed in the parish of Kirkmichael about 1644." (Vol. xii. p. 447).

Dr. Robert Brown heard a tradition in Caithness-shire that the wood on the hills of Yarrow, near Wick, was cut down about the year 1500 by the enraged dwellers in the district on account of its harbouring wolves, and that the last wolf in that neighbourhood was killed between Brabster and Freswick in a hollow called Wolfsburn.

The place where the last wolf that infested Monteith was killed is a romantic cottage south-west of the mill of Milling, in the parish and barony of Port.*

"The devastations of Oliver Cromwell in the vast oak and fir woods of Lochaber are well known, and in 1848 the old people still retained traditions of the native clearances in the same century, when the great tracts south of Loch Treig and upon the Blackwater were set on fire to exterminate the wolves."†

In the Edderachillis district, forming the western portion of what is called Lord Reay's country, a tradition existed to the effect that wolves were at one time so numerous that to avoid their ravages in disinterring bodies from their graves the inhabitants were obliged to have recourse to the island of Handa as a safer place of sepulture.‡

The Earl of Ellesmere, referring to an extract from the journal of his son, the Hon. Capt. Francis Egerton, R.N., written in India, and relating to an apparently well authenticated story of some children in Oude who were carried away and brought up by wolves,§ says: "It is odd that the same tale should extend to the Highlands. I got a story identical in all its particulars of the wolf time of Sutherland from the old forester of the Reay, in which district Gaelic tradition avers that wolves so abounded that it was usual to bury the dead in the Island of Handa to avoid desecration of the graves."

In like manner an island in Loch Maree, Ross-shire, was for the same reason selected for a similar purpose.‖

On the western shores of Argyleshire the small isle of St. Mungo, still used as a burial place, has been appropriated to this purpose from the days when the wolves were the terror of the land, the passage between it and the mainland opposing a barrier which they in vain attempted to cross.¶

In Athole it was formerly the custom to bury the dead in coffins made of five flagstones to preserve the bodies from wolves.**

When treating of the wolf in England it was observed that many names of places compounded of "wolf" indicate in all probability localities where this animal was at one time common. The same may be said of Scotland. Chalmers cites in Rox-

* Nimmo's "Stirlingshire," pp. 745, 750.

† Stuart, "Lays of the Deer Forest," ii. p. 221.

‡ Wilson's "Voyage round Scotland," Vol. i. p. 346.

§ "Ann. and Mag. Nat. Hist.," 2nd series, viii. p. 153.

‖ Macculloch's "Western Isles," quoted in Chambers' "Gazetteer of Scotland," p. 755.

¶ Constable's "Edinb. Mag.," Nov. 1817, p. 340.

** "Statistical Account of Scotland" (1792), Vol. ii. p. 465.

burghshire, "Wolf-cleugh" in Roberton parish on Borthwick Water; "Wolf-cleugh" on Rule Water; and "Wolfhope" on Catlee-burn, in Southdean parish,* to which may be added "Wolflee" or "Woole," on Wauchope-burn; and "Wolf-keilder" on the Northumbrian border. There are also "Wolf-gill land," in the parish and shire of Dumfries, and "Wolfstan," in the parish of Pencaitland, East Lothian.†

Craigmaddie, "the rock of the wolf," in the parish of Baldernock, and Stronachon, "the ridge of the dog," in the parish of Drymen, point by their name to localities in Stirlingshire which were formerly the haunts of the wolf.

Mr. Hardy states (*l.c.*) that on the farm of Godscroft a cairn, now removed, was called "Wolf-camp." It may have been a wolf's den, or perhaps an ancient "meet" of the wolf hunters who were summoned by the sheriff in the days of the early Kings James.

He adds that in 1769 there was a farm called "Burnbrae" and "Wolfland" in the parish of Neuthorn belonging to Kerr of Fowberry. The name seems to imply that it had been held in former times by the tenure of hunting the wolf, lands thus granted being called "wolf-hunt lands," as already remarked under the head of the wolf in England.

In 1756 Buffon was assured by Lord Morton, then President of the Royal Society, "a Scotsman worthy of the greatest credit and respect, and proprietor of large territories in that country," that wolves still existed in Scotland at that date.

William Smellie, the translator and editor of Buffon's "Natural History," thus comments on this statement (Vol. iv. p. 210, note, 3rd edition, 1791), "We are fully disposed to give due weight to an authority so respectable and so worthy of credit; but we are convinced that the Count has misapprehended his lordship, for it is universally known to the inhabitants of Scotland that not a single wolf has been seen in any part of that country for more than a century past."

In asserting that this is "universally known to the inhabitants of Scotland" the translator and editor has erred in the other extreme, for, as has been already shown, wolves were killed in Sutherland within fifty years of the date of his remark and within thirteen years of the date mentioned by Buffon.

It now remains for us to trace the history of the wolf in Ireland.

* Chalmers' "Caledonia," Vol. ii. p. 132.

† Hardy, "Proc. Berwickshire Naturalists' Club," 1861, p. 289.

(*To be continued.*)

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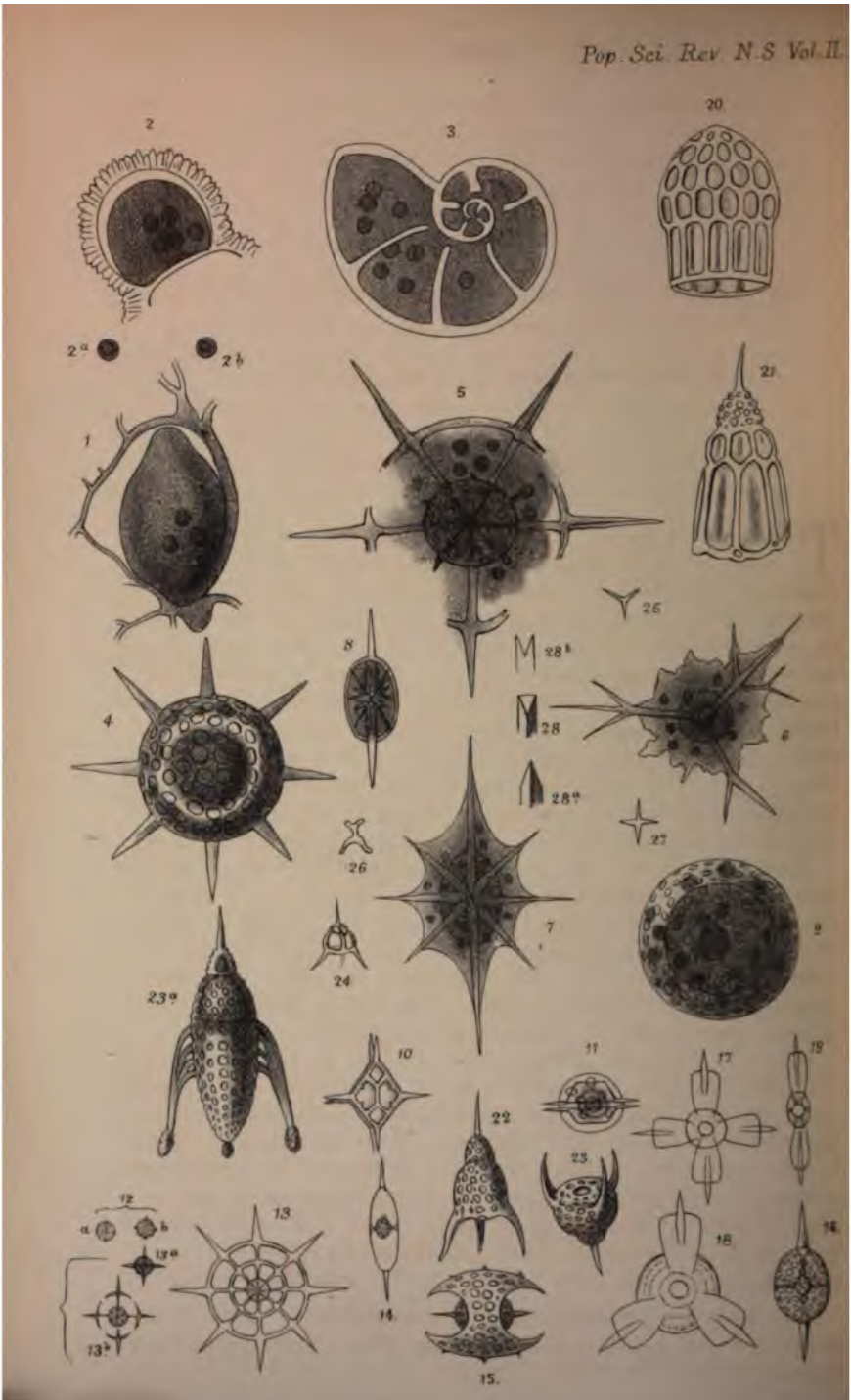

TYPES OF RHIZOPOD STRUCTURE.

ON THE RADIOLARIA AS AN ORDER OF THE PROTOZOA.

By Surgeon-Major G. C. WALLICH, M.D., &c.

[PLATE VI.]

THE publication by Mr. St. George Mivart of an elaborate memoir on the Radiolaria* is undoubtedly an event in the annals of biological literature. Mr. Mivart's reputation as an earnest thinker and accomplished writer, his official position in an illustrious society devoted to botany and zoology, and his well-known antagonism to the "scientific materialism" ascribed by him to a certain school of German and also of British naturalists, are facts eminently calculated to add force and authority to observations emanating from such a quarter. But, on the other hand, they are facts in like manner calculated materially to enhance the difficulty of combating any such observations, the accuracy of which it may become necessary to impugn.

Unfortunately, on the present occasion, Mr. Mivart has not been engaged in chronicling researches carried on by himself; for, if report speaks correctly, he has never yet seen in the living or even the recent condition (from which alone trustworthy results can be secured) the singularly beautiful but fragile organisms whose biological relations he has so laudably, if not altogether successfully, undertaken to expound.

It is true that Mr. Mivart acknowledges at the outset that "his aim has been to furnish a digest and *résumé* of the most recent researches on the Radiolaria," and equally true that from first to last he has so faithfully adhered to his intention as not to have made any attempt whatever to support his inferences, professedly original and comprehensive as these often are, by a single personally attested observation. The bulk of his memoir is in reality a *résumé* of Professor Haeckel's researches on the subject, backed up here and there by supplementary facts

* "Notes touching Recent Researches on the Radiolaria." By St. George Mivart, Zoological Secretary, Linnean Society. The "Journal of the Linnean Society," Vol. xiv., No. 74, May, 1878.

gleaned from those of Cienkowski, Greef, Hertwig, and a few other continental naturalists. From data supplied almost exclusively from these sources, he has constructed a compendium of Radiolarian characters, upon which he bases his revised classification of this Order—an Order, let me observe, which, as now constituted, has only once heretofore been surpassed in the utter incongruousness of many of its elements—that is to say, in 1838, when Ehrenberg, the great pioneer of our knowledge of the lower forms of animal as well as of plant life, whilst the microscope was as yet little more than a toy, published his magnificent work "Die Infusionsthierchen."

The names of a few British and American naturalists, accompanied by a very incomplete list of their writings, are furnished at the close of Mr. Mivart's memoir. As this, with one or two unimportant exceptions, is the only direct notice accorded them, it may be fairly inferred that his estimate of their labours on the Radiolaria tallies with that recently expressed by the late Director of the "Challenger" expedition; namely, that "the Radiolaria which play so important a part in supplying the materials for new geological formations are not very familiar to British naturalists." *

It shall be my endeavour to show, incidentally, in the course of the following remarks, that British naturalists have at any rate taken their fair share in the investigation, and have only acted with a commendable caution which might with advantage have extended further, in hesitating to devote their energies to the disentanglement of an assemblage of creatures which was day by day proving itself to be more thoroughly arbitrary. Mr. Mivart would seem, however, to be unaware that until a very recent date the Radiolaria, as recognized by the majority of British writers, comprised but four families, namely, the *Actinophryna*, *Acanthometrina*, *Polycystina*, and *Thalassicollidæ*; that very detailed observations have been published by English writers on the morphological relations of each of these families; and that it is to this hour an open, though I cannot believe a doubtful, question, whether the Radiolaria, as constituted by Haeckel and now revised by Mr. Mivart, ought to be retained as a Natural Order of the Protozoa, or abolished as being one which is purely artificial, misleading, and consequently worse than useless.

Professor Haeckel is known by those who have read his works to be the unflinching advocate not only of the doctrine of *Evolution* in its most advanced sense, but of *Spontaneous Genera-*

* "Voyage of the 'Challenger.' The Atlantic." By Sir C. Wyville Thomson, Knt., LL.D., D.Sc., F.R.S.S.L. & E., F.L.S., F.G.S., &c., Vol. i., p. 231.

tion.* Imbued with an unquestioning faith in the truth of these doctrines, he is a perfect Stoic in pressing them, through good report and bad report, to their final consequences. No writer of the present century, except Ehrenberg, has added so copiously to the literature of the lower forms of animal life; none has striven more zealously to make the most of his material. But I undertake to say none has been so blinded, both in his powers of observation and of deduction, by an overwhelming subservience to preconceived hypothesis.

As already stated, Mr. Mivart has made Haeckel's writings the almost exclusive groundwork of his memoir. Under ordinary circumstances, and in default of personally acquired experience, the ready adoption of the opinions of so distinguished a naturalist would hardly be a matter for wonder. But when there exist the strongest reasons for considering Mr. Mivart's *conclusions* as fallacious as many of the assumed facts upon which he bases them; and it can be further shown that no other writer has ever levelled a more severe indictment against Haeckel than Mr. Mivart himself within a quite recent period, an appeal to facts rather than to mere authority cannot, I should imagine, be regarded as out of place. In order, therefore, to put this statement beyond reach of question, I invite attention to the subjoined passage, one only out of several equally incisive, from Mr. Mivart's volume on "Contemporary Evolution," published just two years ago.†

"Amongst the most recent manifestations of scientific materialism may be cited Professor Haeckel's 'History of Creation.' Professor Haeckel is a very instructive writer, because his zeal for materialistic pantheism is so fiery that it hurries him sometimes into atheistic *deductions from supposed facts, which later investigations prove to have been fictions* (*e.g.* the supposed organism *Bathybius Haeckelii*‡, too pro-

* "The History of Creation." By Professor Ernst Haeckel. Translated from the German. Vol. i., pp. 234, 244, and Vol. ii., pp. 53, 278, &c.

† "Contemporary Evolution." By St. George Mivart. King & Co., London, 1876.

‡ The writer of the present article stood absolutely alone, for many years, in his endeavour to expose this monstrous fiction; and so strong was the influence of a great name, that his objections, *all* of which have since been fully borne out, were discredited. On the other hand, Professor Haeckel (the selected sponsor for this *nidus maris*), Dr. Carpenter, and Sir Wyville Thomson, forthwith received it under their patronage, and announced in the "Proceedings" of the Royal Society, almost before the first echoes of Professor Huxley's discovery had died away, that they, too, had come across *Bathybius*, living, spreading out far and wide in one vast sheet over the entire bed of ocean, and in every particular answering to the characters claimed for it. As for Professor Haeckel, he lost not a day in figuring and describing *a*

bably but a sea mare's-nest, discovered by Professor Huxley, and appropriately named by him after his German *alter ego*), sometimes into a ludicrously exaggerated estimate of the philosophical or theological consequences of elementary truths, *e.g.* those of development." (Op. cit. p. 145.)

Mr. Mivart has done me honour to mention in his list of works on the Radiolaria, published *since* the appearance of Haeckel's monograph "Die Radiolarien" in 1862, my "North Atlantic Sea-bed," published also in 1862; my paper on "The Structure and Affinities of the *Polycystina*," published in 1865; and my "Observations on the *Thalassicollidæ* and *Collosphæridæ*," published in 1869; the remark being appended to the last notice that "no mention was therein made of Haeckel's monograph." It may be allowed me, therefore, to point out that my "North Atlantic Sea-bed" was *not*, as alleged (indeed the date Mr. Mivart gives sufficiently attests this), issued *after* Haeckel's monograph; and that one reason alone deterred me from alluding to the latter in 1869—a reason Mr. Mivart compels me now to divulge—namely, the desire to avoid giving utterance to an opinion upon Professor Haeckel's method and the errors springing out of his "fiery pantheism," which, if expressed at all, could not have fallen far short of Mr. Mivart's, or been so lightly formed as to become so soon forgotten. Besides, had he taken but a little more trouble in the perusal of my paper "On the *Polycystina*," he would at once have seen that I therein, whilst referring directly to Haeckel's monograph, did my best to explain, in most guarded and courteous language, my disinclination to comment unfavourably on a method of building up a superstructure which appeared to me to be so full of danger.

I feel, therefore, that the time has arrived for demonstrating the fallacy, on the one hand, of splitting up into a number of trivial groups, and genera, and species, an assemblage of organisms so pre-eminently distinguished for an almost endless tendency to variation as the whole of the Radiolarian families; and, on the other hand, of attempting (according to a system

living specimen as seen with his own eyes. Those who desire to trace the history of the rise and fall of this prodigious fiction will find it in the following papers:—

"On the Vital Functions of the Deep Sea Protozoa," by G. C. Wallich, M.D., &c., "Monthly Micr. Journal," January, 1869.

"On the True Nature of the so-called *Bathybius*," by the same Author. "Annals and Mag. Nat. Hist.' for November 1875.

"Deep Sea Researches—The Biography of Globigerina," by the same Author. John Van Voorst, London: 1876.

"e Coccosphere," by the same Author. "Annals," Apr. 1877.

growing far too prevalent with a certain class of naturalists) to assign a place in this already heterogeneous sub-kingdom, to every previously unknown microscopic structure that oceanic or fresh-water sources reveal to us; inasmuch as this system is already reducing the study of the lower forms of animal life to a state of chaos from which it will, probably, take years to recover. This must, I think, become manifest to anyone fairly versed in the literature of the subject, who will unprejudicedly examine Mr. Mivart's memoir, keeping constantly in recollection that the author is all the while dilating on observations made wholly by others; and that the constant appeal, for purposes of diagnosis, to the most immaterial differences; the as constant substitution of assumed for observed facts; the bolstering-up of most indefinite "definitions" by an array of qualifying and relative terms, until at last they may be made to mean anything or nothing; the creation of a ponderous, and not unfrequently not very classical nomenclature; and, lastly, the inexcusable practice of re-naming organisms, or parts of organisms, already named, described, and even figured by prior observers, are, in the main, the work of a school of Evolutionists who might with reason have been expected to utilize the motley Radiolarian assemblage, as being of all others the best-fitted for the illustration of their doctrine. Yet, incredible though it may seem, the staunchest believer in "Fixity of Species," if he happened to be unaware of the extent of variation to which the Rhizopods generally are liable, could hardly have gone further in species-manufacture. And to make the matter still more wonderful, whilst Mr. Mivart tells us, in highly eulogistic terms, that Haeckel's "Die Radiolarien" contains a description of *a multitude of new genera and species* (Memoir, p. 139); we are gravely informed by Sir Wyville Thomson that, "the Radiolaria form a class of the *somewhat negative* sub-kingdom Protozoa, which is retained for the reception of those animals of comparatively simple structure, *such as the Infusoria* (!), &c., WHOSE RELATIONS WE CANNOT VERY FULLY MAKE OUT" ("The Atlantic," Vol. i. p. 231); so that here we have the writer who, naturally enough, is regarded just now as the latest and most experienced authority on the *Radiolaria*, openly avowing that he regards them as the scientific waste-paper bag to which may be advantageously consigned all manner of creatures belonging to the lower forms of life of which we know nothing!

But it is for Mr. Mivart, the author of "Contemporary Evolution in 1876," to reconcile, if possible, the charge therein brought by him against Haeckel, with the following panegyric on Haeckel's monograph "Die Radiolarien," pronounced by Mr. Mivart, the author of "Notes touching Recent Researches on the

Radiolaria," in 1878; to wit, that "had this illustrious naturalist done no other scientific work than the publication of his magnificent and classical work 'Die Radiolarien,' that work alone would suffice to procure him everlasting fame." (Memoir, p. 139.)

Haeckel's is undoubtedly a magnificent work, and one pregnant with the results of almost unparalleled industry and study. But its utility is marred beyond redemption by the unconcealed resolve to work out, and *down* to, an all-engulfing hypothesis which renders it impossible for anyone but a professed disciple of the Haeckelian method to accept its teachings. Of course, of intentional misdirection no one would dream of charging Haeckel. Whenever he errs, it is because he is Haeckel—the slave of a dominant idea—of the "fiery pantheism" and point-blank materialism that blind him to everything but the goal he is rushing towards.

But I must not be misunderstood. In offering this commentary on the opinions entertained by Professor Haeckel, I do not even assail his hypotheses *as* hypotheses. Both of them may turn out to be true. Evolution has already been proved to be a method of Nature. But, without its being at all requisite to admit that Haeckel's *primordial slime* was, at some anterior epoch of the earth's history, spontaneously generated, I candidly confess I see no reason whatever for regarding it as impossible for the chemist to succeed in evolving, out of the inorganic elements and natural forces at his command, a compound capable of evincing vital activity. What I do assail is, the tendency of the Haeckelian method to gallop on altogether in advance of demonstrated fact, beyond which the scientific biologist is not warranted in advancing by a single hair's breadth. All he may legitimately do is to use his hypotheses as such only. The moment he does more, and permits himself to talk seriously of an admitted "assumption," on which he has already based a system, as having "been proved to be a necessary hypothesis"—in other words, claiming the right to say *necesse, ergo sit*, he merges at once into the mere speculator, the foundations of whose edifice are of sand.*

It is quite inexcusable enough for systematists to persist in applying a definite term to a portion of structure which belies the very definition it conveys, and to make what is little better than an unsupported assumption the basis of such an erroneous and yet positively stated dictum as the following:—"The *yellow cells*† are undoubtedly *cells* multiplying by spontaneous division of their cell contents, each division surrounding itself by its own

* See Haeckel's "History of Creation," Vol. ii. p. 278.

† See on p. 274.

cell wall before the dissolution of the mother-cell." (Memoir page 145.) But such a dictum becomes sheer nonsense after its having been gravely laid down on the authority of Cienkowski that these *yellow cells* (described in the page preceding as being "very characteristic of the whole of the *Radiolaria*, except some *Acanthometra* forms"), "were found vigorously multiplying in *dead Radiolaria*;" and that Cienkowski "suspected that they may be *parasitic organisms*;" whilst Hertwig, it is said, opposed Cienkowski's view on account of the constancy of the presence of the *yellow cells* in the *Radiolaria*, on which Mr. Mivart, with singular naïveté, remarks:—"But undoubted parasites are present with remarkable constancy in many higher animals, while several difficulties disappear if we regard them as parasites. It would (he says) first account for no other satisfactory explanation of their origin having been arrived at; secondly, for their greatly varying number; thirdly, for their survival and increase amidst the decomposition of the individuals in (*sic*) which they live; and lastly, it would explain the anomaly of *unicellular animals* containing true cells." (Memoir p. 145.)

At p. 144 it is stated that "certain peculiar structures, namely, the *yellow cells*, are very characteristic of the Radiolaria, being found in *all*, except some *Acanthometra* forms. They are nucleated, and their protoplasmic contents *are enclosed in a distinct membrane*." Whilst, in reference to the question as to whether unicellular animals can contain true cells within themselves, as part and parcel of their organization, Mr. Mivart continues as follows: "Without venturing to express an opinion on this controversy, I would place on record that Hertwig has come to the conclusion that a multinucleolate cell is potentially multinucleate, as a multinucleate cell is potentially multicellular; and *thus* we get a transition from unicellular to multicellular organisms. . . The multicellular nature of the Radiolarians now depends entirely on the normal nature of the yellow cells, and on the correctness of the observations of the centripetal cell-groups of *Physematium*. As has been said, *neither of these phenomena can be reposed on as being certainly of the nature of true cells, forming part of the normal organization of the Radiolarians* in which they have been found; but even if they are so, and if we are compelled, therefore, to regard Radiolarians as multicellular, their multicellularity is of a radically different kind from that of any of the METAZOA; and none of their parts, whether true cells or not, have any valid claim to the denomination of a *tissue*. (Memoir, pp. 182, 183.)

We shall see hereafter that their true cell nature is very distinctly maintained, nevertheless; or if not so, that the absence

of a *nuclear vesicle*, which is adopted by Mr. Mivart as the most prominent and important feature in six-sevenths of the whole of the *Radiolaria*, is contra-indicated in every one of these six-sevenths (with exception of the *Polycystina*, one group which, as I have never ceased to contend, ought not to be associated with the other groups, but with the Foraminifera in the first Rhizopod order), in consequence of this very deficiency as regards a *definite nucleus*—that is, a truly *encapsuled* nuclear mass.*

But speculative philosophy and *naïveté* go yet a stage further; for Mr. Mivart informs us that his *deus ex machinâ*, "Haeckel, *speculates* as to the possibly HEPATIC nature of the yellow cells, considering it to be not unlikely that they may be AN INCIPIENT FORM OF LIVER. But in the first place these cells may, as has been said, be PARASITIC; and secondly, a liver is, as it were, a comparatively late result of tissue formation, and could HARDLY exist in the admittedly tissueless Protozoa!" (Memoir, p. 158.)

In 1863 I pointed out, for the first time, that the so-called yellow *cells*, as also more or less perfectly colourless, but in other respects perfect homologues of them, are present throughout *all* the Rhizopodal families, both oceanic and fresh water; this statement being based on long personal experience. At the time indicated, they had been observed by others only in three *pelagic* families, namely, the *Polycystina*, the *Thalassicollina*, and the *Acanthometrina*; their brilliant yellow tint in the pelagic families being regarded as their distinguishing character, until it was shown by me that absolutely identical bodies (see Pl. VI., figs. 1–3, 5, 6), in all save colour, are common, as before stated, to the entire Class. Their office had, moreover, until then been either altogether unrecognized, or, so far as I am aware, referred to only more or less incidentally as in some manner connected with reproduction.

It was in the course of a laborious day-by-day series of observations on the fresh-water and littoral Rhizopods, extending over the greater part of the years 1863 and 1864, that I was enabled to compare and trace clearly and consecutively the mode of origin of these remarkable bodies, and to prove beyond all reasonable doubt that they constitute a true reproductive organ, formed either *directly* (as may be witnessed in the Foraminifera of our own shores) by the aggregation into minute spheroidal masses of granular, probably germinal, particles, which, up to the period of this change taking place, are more or less uniformly distributed through the sarcode mass generally; or, *indirectly*, by the subdivision of the contents of the granular nuclear mass itself, without, however, acquiring in any instance

* See my classification at the close of this article.

the *nucleus* of the higher order of Rhizopods invariably does) membranous covering. For these combined reasons which obviously made the term "*yellow cells*" a dangerous misnomer, I designated them *sarcoblasts*. Whether, in the fresh water, the littoral, or oceanic Rhizopods, *the sarcoblasts invariably constitute*, when liberated from the parent organism (which they are always eventually destined to be), either at once the adult shell-less organism, as in the naked Rhizopods; or the *nucleus*, and at the same time the infant mass of sarcode, within which the rudiment of the shell or other mineral framework of the organism is secreted. Thus, in the *Amœbans*, the sarcoblasts speedily assume, one by one, the whole of the typical characters of the parent form. In the *Foraminifera* and *Polycystina*, they are the *nidus*, within which, in the former family, the primordial calcareous chamber of the shell is secreted, and in the latter family, the earliest siliceous rudiment of the siliceous framework or perforated shell; whilst in the *Acanthometrina* and other families constituting the second Order, in which an *enveloped nucleus* first presents itself, they form the *nidus*, not only within which the axial portion of the siliceous framework is secreted, but also within the peripheral portion of which the earliest discernible vestige of the membranous capsule is secreted, in the condition of a most subtle membrane. Indeed, so fully is this fact borne out by observation that it may, I venture to believe, be laid down that until the sarcoblast has already become freed from the parent structure, no trace whatever of the nuclear capsule exists.

For the above stated reasons, (which I submit, demand something more for their refutation than speculative disquisitions about the unicellular or multicellular potentialities of the Radiolaria, or about their incipient *Liver-systems* and *parasites*), I have considered it absolutely necessary to substitute the term *sarcoblasts* for that of *yellow-cells*, as being not only suggestive of the derivation and function of these bodies, but as avoiding the condition as to colour, which is altogether untrue in the case of the fresh-water Rhizopods.

But after what has been stated concerning the opinions of Professors Haeckel and Hertwig, Sir Wyville Thomson, and Mr. Mivart himself on the nature and origin of the *yellow-cells*, I can surprise no one that the term *sarcoblasts* should not have been very readily adopted by any of these writers. Mr. Mivart tells us at the outset of his observations, that "each individual Radiolarian consists of two portions of coloured or colourless sarcode; one portion nucleated and central; the other portion peripheral and almost always containing certain *yellow-cells*; these portions being separated by a porous membrane, called a 'capsule'" (Memoir, p. 137), it being added in a footnote

that, according to the opinion recently offered by Sir Wyville Thomson, it is probable that the *capsule* does not present itself in some of the Radiolarians.

Having for twenty years maintained that the *Polycystina* do not possess a true "definite nucleus"; or, as described by me, no true encapsuled nuclear mass; and that they must on this account rank with the Foraminifera, the sarcode bodies of which are similarly constituted, and cannot, therefore, even under the most strained interpretation of their characters, be grouped naturally with the so-called "Radiolaria;" it is requisite that I should call attention to the opinion quite recently expressed by Sir Wyville Thomson regarding these organisms, after having had nearly a year and a half to maturely weigh all the evidence he was so fortunate as to secure during his explorations on board the "Challenger."

Sir Wyville's work, "The Atlantic," was published at the close of 1877, that is to say, nearly a year and a half after the return of the expedition. At page 231 of the first volume, the subjoined far from encouraging description is given of the Radiolaria; namely that "they form a *somewhat negative class of the sub-kingdom* Protozoa, which is retained for the reception of those animals of comparatively simple structure *such as the Infusoria*, &c., WHOSE RELATIONS WE CANNOT YET FULLY MAKE OUT."

Again, at p. 232 of the same volume, the Radiolaria are described by him as "consisting essentially of rounded or ovate granular masses of brownish or yellowish colour, interspersed with very characteristic round oil-globules, bright yellow, and very refractive, the whole cemented together by soft, transparent sarcode, including fine granules. Near the centre of the body there is usually a very evident rounded mass of *bioplasm*, which colours deeply with carmine; and the same dye brings out smaller BIOPLASTS scattered irregularly through the general substance."

Thus we find on a comparison of these descriptions:—First, that the "granular masses" mentioned are not identical with the bodies afterwards referred to as "smaller *bioplasts*"; secondly, that "the characteristic round oil-globules" are not identical with the granular masses just referred to; and, thirdly, that the "*smaller bioplasts* scattered irregularly through the general substance," must necessarily be yellow cells or, in other words, SARCOBLASTS.

This portion of the Rhizopodal structure is, in reality, a small spheroidal mass of sarcode, generally varying in size in the different families within certain limits, and wholly devoid of any true membranous or other special covering. When first observable, it consists of an almost colourless, hyaline, viscid, and basal fluid, of the consistence and appearance of the white of

egg, within which are distributed peripherally, but without any approach to regularity, a number of granules of more consolidated, as well as more or less faintly coloured sarcodic substance (fig. 2 *a*); and invariably (I believe) in the case of the sarcode of the oceanic Rhizopods, of a tolerably brilliant yellow tint. But by carefully focussing down to an equatorial plane, a central portion, altogether devoid of granules, and occupied solely by the pure basal sarcode, may quite readily be detected (fig. 2 *b*). It is to this clear portion that the somewhat misleading name of *nucleus* has been applied; perhaps owing to the idea that its apparent higher degree of refractive power, as compared with the surrounding mass of the animal's sarcode, may be due to its being a specialized product; or, in other words, not identical with the basal ungranular sarcode of the rest of the sarcoblast itself, and of the general body substance in which granular particles are almost always, more or less densely, suspended. Through some subtle reproductive operation, of which we as yet have learned nothing from actual observation, in consequence of the extremely minute nature of the particles concerned, the yellow granules become, after a time, collected together into the spheroidal masses now become sarcoblasts; and, possibly, two sexual elements are, at this stage of the organism's history, brought into contact. It will, I hope, be clearly understood, however, that I throw out this view simply as a surmise, resting on no more stable basis than a fact observed by myself, and for the accuracy of which I am ready to vouch with perfect confidence, that the so-called nucleus of the sarcoblast becomes eventually, on the escape of that organ from the parent structure, the active centre of shell or skeleton-development. But on this subject I shall have more to say hereafter.

We are hence almost irresistibly led to the conclusion that the truly *constructive* "germinal" substance of the Rhizopod is the hyaline, homogeneous, viscid, and ungranular portion of the sarcode; whereas the granules and every other portion forming an integral part of the structure, are developments from this, and constitute true "formed material"; this view holding good both as regards the entire mass of the body in the youngest stage of the naked *Amœbans*; in the earliest formed chamber of the *Foraminifera*; and also in the earliest stages of the *Polycystina*, *Plagiacanthidæ*, *Acanthometrina*, and *Dictyochidæ*, in which the siliceous structure constitutes an internal framework or skeleton, rather than an external shell. Whilst throughout the entire series of the Rhizopodal families, wherever there exists a mineral fabric of any kind, whether shell, framework, groups of spicules, or shell composed partly of mineral matter elaborated by a vital operation of the creature, and partly of altogether extraneously derived mineral particles,

all are more or less invested exteriorly by a delicate film of sarcode, which (as long ago pointed out by Professor Williamson, as being characteristic of the *Foraminifera*) is an effective agent in increasing *exogenously* the thickness and extension of the mineral portion, of whatever nature the latter may be.

In short, as tersely put by Dr. Carpenter, whilst describing the perfectly developed cell-formation observable in the higher animals, the nucleus may be regarded as *the seat of the cell's formative activity.** So in the sarcoblast (which is *not* a cell, and is therefore in no respect more entitled to the appellation of the term "cell" than a globule of oil, albumen, or other viscid fluid, notwithstanding that it comprises one portion more consolidated or specialized than the other), the central region is "the seat of *its* formative activity"; this very instructive fact having been, as already stated, completely verified, by what has been observed by me to take place, both in the marine and freshwater Rhizopods.

But the great importance of arriving at a definite and correct conception respecting this part of the Rhizopod structure will presently be made apparent on other and even stronger grounds. Meanwhile it must be mentioned that Mr. Mivart attempts, amongst other things, to determine "whether or not the resemblance, insisted on by some writers, as existing between the *Radiolaria* and the *Heliozoa* is such as to render it desirable to unite them as two subdivisions of one larger group, itself distinct from all the other groups of Protozoa." Hertwig, he says, "in his latest paper on the histology of the Radiolaria, leaves the question undecided whether the *Heliozoa*, *Radiolaria*, and *Thalamophora*, should constitute three distinct and co-equal groups; or one great group should be made to comprise the *Heliozoa* and *Radiolaria* only, the other being set aside for the marine and freshwater *Thalamophora*; Hertwig having in a prior paper denied the relationship of the *Heliozoa* to the *Radiolaria*," on the ground of the supposed cell-structure both of the external and internal alveoli, and "also of the *Wasserhellen Bläschen*,† as well as on other accounts." Mr. Mivart, however, goes on to say that as Hertwig is now satisfied that "alveoli are but *vacuoles*, without membranous walls, and that the *Wasser-hellen Bläschen* are but *nuclei*, his reasoning falls to the ground;"—a conclusion in which I heartily coincide.

The similarity of the *Heliozoa* and *Radiolaria* in external form and chemical composition, Mr. Mivart regards as undeni-

* Carpenter on "The Microscope," p. 734. Fifth ed., 1875.

† These are said to be "rounded homogeneous particles of denser sarcode, devoid of investing membrane; and to be the 'simple nuclei'" of authors. (Memoir, p. 141.)

able; but, on the other hand, very many Radiolaria, according to Hertwig, depart widely from the spherical form; and similarity of chemical composition * cannot, therefore, be considered a distinction of great weight, seeing that such similarity is shared with many other lowly organisms of quite different affinities. (Memoir, p. 181.)

With reference to the reproduction of the *Radiolaria*, Mr. Mivart informs us that it "*undoubtedly* takes place by means of numerous ZOOSPORES, each with a *nucleus* and FLAGELLUM, but with no vacuoles; whereas in the *Heliozoa* the much fewer separated reproductive parts have each two *flagella* AS IN MOST RHIZOPODS (!), several contractile *vacuoles*, and a *nucleus*, with *vacuoles* and *nucleoli*." These differences he considers as so great that he warns us (as indeed he well may, considering that he does not shrink from laying down as regards the reproduction of the *Radiolaria* "by *spores*," that "it is *certain* that such a process occurs in *Acanthometra*, *Thalassicolla*, *Sphærozoum*, *Collosphæra and Collozoum*, and most probably in ALL the Radiolaria." (Memoir, p. 167.) And again, that "there are also great differences in this respect between different *Heliozoa*, *while the reproductive processes of so few Radiolarians have as yet been examined, that it would be rash to feel confident that no important divergences will hereafter be found to exist among them in this respect!*" (Memoir, pp. 180, 181.)

I candidly confess to feeling confounded, and at an utter loss even up to this point to reconcile these seemingly diametrically opposed opinions; or to comprehend what "further important divergences" should be needed than the all important one to which Mr. Mivart himself draws attention, and constitutes No. 4 in his list of distinctions categorically given (at p. 180) between the *Radiolaria* and *Heliozoa*; namely that "*yellow cells* are present in almost all Rhizopods, but absent in *Heliozoa*;" that is to say if he, or rather those writers on whose opinions he is placing his trust, choose to insist that because the sarcoblasts of the freshwater *Actinophryans*, in common with the rest of

* I have been altogether unsuccessful in tracing to whose chemical analysis of these microscopically minute structures we are indebted for this apparently decided judgment upon their elementary constitution. Under all the circumstances I would humbly suggest that it will be a long time, indeed, before any *differences* in the chemical composition of such subtle organisms can be determined by any re-agents at the chemist's command. In the very nature of things, identity, or apparent identity, must be far more easily indicated. But be this as it may, when it is borne in mind that it is unreservedly asserted that "The *Radiolarians* live on Algæ, Diatoms, and Infusoria, and other small animal and vegetable organisms found near the surface of the sea," it must, indeed, be a difficult task to ascertain where ch[illegible] is dealing with the mere animal's body, or with its vi[illegible]

the freshwater Rhizopods, are not yellow, the one variety is not the true homologue of the other; or unless he really adopts the almost ludicrous view enunciated by Cienkowski that the "*yellow cells*" of the *Radiolaria* are "*parasites*."

But the climax has yet to come. It has been already stated that, according to Mr. Mivart's *résumé*, "the central nucleated portion of the Radiolarian sarcode, and the peripheral portion which almost always contains *yellow cells*, are separated by a *porous* membrane called the 'capsule';" and that he quotes Sir Wyville Thomson's opinion that this "*capsule*" is frequently altogether absent. Here are Sir Wyville's own words: "In many Radiolarians, and especially in some very peculiar compound forms, a spherical internal chamber called the "central capsule," whose functions we do not fully understand, is very prominent. *This capsule is however absent, or at all events exists in a very modified form* IN THE MORE TYPICAL *groups*." Had Sir Wyville Thomson particularized but one step further, he would probably have announced that, as always consistently urged by me, one most important family of the Radiolaria, as constituted by Haeckel, and adopted by Sir Wyville Thomson and others on Haeckel's authority which in turn probably rested on Johannes Müller's, is pre-eminently *the* typical one which possesses no encapsuled nucleus, or (to use the new designation) no "central capsule"; and that, if the classification of the Rhizopods is to be based as far as practicable on the physiological advances observable in the sarcode bodies of the animal, the absence of this "capsule" at once ratifies my conclusion that the place of the *Polycystina* is essentially alongside of the *Foraminifera* in the lowest Rhizopodal Order, and *not* with the so-termed *Radiolarians* in the second or higher Order.

But how does Mr. Mivart meet this significant, though, as already pointed out, by no means novel discovery of Sir Wyville Thomson's—a discovery, be it observed, upon the correctness or incorrectness of which the question of the propriety of associating the *Polycystina* with the families of the second Order of the Rhizopods was fifteen years ago shown by me to depend?* Is it by adducing good evidence of its error? Or by admitting that, if not an error, the entire fabric of the *Radiolaria*, as a whole, is unsound? Or by inserting in his *résumé* of all previous researches on the subject, that at least one writer on the oceanic and freshwater *Protozoa*, not only published the bare fact mentioned by Sir Wyville Thomson, but produced ample evidence in support of it? No! But by appending in a footnote the following singular commentary:—"If Sir Wyville

* In the very paper on the *Polycystina* which Mr. Mivart notices in his list.

Thomson's opinion is not a *clerical* error, some very interesting new forms may be expected to be made known by the publication of the "Challenger" Zoology; but whatever novelties may be forthcoming, forms without a central capsule should be excluded from the *Radiolaria*."

However, with two such admissions before us:—the one that the "porous membrane called the capsule," held by the supporters of the Radiolarian classification to form its most important characteristic, "is *absent*, or exists only in a very modified form in the more *typical* groups;" the other, "that forms without a central capsule should be excluded from the *Radiolaria*;" there is evidently good ground for hoping that "this somewhat negative class of the Protozoa which," according to Sir Wyville Thomson, "has been retained for the reception of animals of comparatively simple structure, such as the *Infusoria*, whose relations we cannot fully make out," may—to use an expression now rendered classical—be abolished "*bag and baggage*."

It is desirable to mention here that in such *Polycystina* as that figured at page 140 and again at page 150 of Mr. Mivart's memoir, under the name of *Eucecryphalus Schultzii*, and also in the genera *Pterocanium*, *Lithocampe* and others, the division of the sarcode-body into two or more lobes which are to be seen, in the recent condition of these organisms, projecting towards the mouth of the shell from its innermost and uppermost portion, is not due to the presence of a membranous support, as has often been erroneously imagined; but merely to the sarcode being prevented from forming itself into a single bulging mass (such as we see within the aperture of the tests of *Arcella* or *Difflugia* when the animal is at rest), by festoon-like processes sent off from the interior of the primary chamber; these processes having the effect of constricting the sarcode where it impinges on them, without, however, interfering with its free coalescence posteriorly. At the same time, if we may judge from what is observable in *Arcella*, it is probable that when the animals of the *Polycystine* genera above named are in their natural element, the lobes may disappear through the flow forwards of the dense and sometimes more deeply tinted portion, which, in captured specimens, is usually found occupying the innermost part of the shell, both in the *Polycystina* and in some species of *Foraminifera*. Accordingly, the occurrence of the lobes referred to, though furnishing a good distinctive character derived from the peculiarity in the configuration of the siliceous framework, does not indicate either structural or physiological advance. For this reason I have thought it necessary to call attention to it.

[*To be continued.*]

HOW WERE THE EOCENES OF ENGLAND DEPOSITED?

By J. STARKIE GARDNER, F.G.S.

IN this inquiry it will be necessary to pre-suppose that my readers are more or less familiar with that great series of Tertiary rocks in England known as the Eocene. I will, however, briefly recapitulate the subdivisions into which geologists have grouped it, and their several characteristics; and will then see how far the facts that have been gathered may be connected into a perfect chain of events, and a consecutive chapter in the earth's history constructed from them.

The Eocene, or "New Dawn" age, is, in England, the newest formation present in great thickness, and also spread over a wide area. We possess more recent deposits, such as the "crags" of Suffolk and Norfolk, and Pleistocene clays and gravels scattered here and there; but these are not parts of any of the great systems of strata which form, to a considerable extent, the solid crust of our earth.

Reference to geological maps of England shows that the Eocenes are at the present day almost confined to two great areas, severed from each other by Chalk ridges. One of these is known as the "London Basin," the other as the "Hampshire Basin." There are other "basins" in France, Belgium, and North Germany; and in Italy, Austria, and Switzerland there are many local Eocene deposits containing faunas, and more especially floras, which have not yet been carefully separated from the overlying and, in those countries, better developed Miocene.

It must not be supposed, however, that, in Western Europe at least, the Eocenes were originally deposited in isolated basins; but being, as they are, the uppermost deposits and loosely compacted, they have, speaking generally, only resisted denudation in the areas which have remained depressed, and have been swept off those districts which have since been elevated into ridges. There is abundant evidence to show that all these "basins" are but the remains of more or less continuous sheets of strata which formerly covered the intervening areas.

Eocène Inférieure.—The lowest members of the Eocene, known *Eocène inférieure* of France and Belgium, are altogether

wanting in England, and a gap of incalculable age, only slightly lessened by these on the Continent, exists between our lowest Eocene and the Chalk upon which it rests.

Thanet Sands.—These, the lowest Eocene deposits present in England, rest unconformably upon the Chalk. They are confined in England almost to the eastern area of the London Basin, but spread over Picardy and Flanders as the *Sables de Bracheux*, and in Belgium are known as the *Landénien inférieur*. They indicate a very temperate climate.

Woolwich and Reading Beds.—In the Hampshire Basin these are entirely unfossiliferous mottled clays derived from granite, and of fluviatile origin. Eastward, near London, lignites and sands with brackish-water shells come in. Further east the fluviatile mottled clay disappears, and the horizon is occupied by marine sand with estuarine shells. A flora was found near Reading, valueless for climatal inferences; but from the presence of palm wood, sharks' teeth and turtles elsewhere, it appears that the climate was perhaps even sub-tropical, but still far less hot than it became in the time of the London Clay.

Oldhaven Beds.—These consist of great beds of rolled shingle and fine sand, containing sometimes estuarine and sometimes marine shells; they are confined to the eastern area of the London Basin.

London Clay.—This is a compact mass of clay of great thickness, and spread over both the English "basins" and Belgium. It is divided into zones deposited in shallow water, which occur at the base; and deposits from deeper water, but not estimated at more than 100 fathoms, which form the upper part of the series. Only the beds characterized by shallow water mollusca are found in the western area. In addition to the marine fauna, a terrestrial fauna and a flora of great extent are known, and it is remarkable that these latter present a far more tropical assemblage than do the marine products. The beds at Sheppey appear to have formed a great river delta.

The Lower Bagshot Beds.—In the west these are pipe-clays and sands, derived, as were the older mottled clays, from granite, and deposited in fresh-water. Towards and east of London they are entirely composed of shingle and sand worn from chalk flint and left by the sea. The rich flora contained in this series at Studland and Alum Bay forms a similar group to that, the fruits of which are found at Sheppey.

The Bournemouth Series.—From Studland to a mile east of Bournemouth, these are purely fresh-water delta deposits. They are then overlain by marine or brackish delta mud, by shingle and sand, and by a sequence of marine strata at Hengistbury Head. This series is particularly interesting, as in it we can trace step by step one of the numerous subsidences which took

place in Eocene times. The flora shows a gradual change from upland-character to valley and to swamp—then lagoon conditions are traced, shingle and sea sand, and finally open sea deposits. A noteworthy fact is that in the marine beds we have fruits which, although comparatively few in number, are important, because similar to or identical with those from Sheppey.

Bracklesham Series.—A mass of marine sands distinguished lithologically from the London-Clay series, by the presence of green grains. The marine fauna is totally distinct and far more tropical than that of the London Clay, whence it is inferred that these beds were deposited in a sea shut off from the more northern London-Clay sea. They occupy most of the Hampshire Basin, and are traced in the London Basin as far as Chertsey, but their principal extension is in the Paris area. They appear in England to have been deposited in the quiet estuary of a great river, and are partly contemporaneous with the Bournemouth series.

Barton Beds.—These are marine deposits occupying a limited area. Although separated by a greater lapse of time, their mollusca far more closely resemble those of the London Clay than do those of the Brackleshams; many species of the latter which had disappeared now reappearing. The fauna has in fact a more northern facies than the Bracklesham fauna, only twenty per cent., and these the more temperate mollusca, remaining.

The Upper Bagshot Beds.—These are mostly white siliceous sands. Mr. Godwin-Austen has shown that the sudden succession of sand to clay involves no physical change. The fauna, where present, is of the Barton type.

The Upper Eocene.—The remainder of the Eocene strata in England are of fluvio-marine origin, and 560 feet thick. They are alternations of marine, brackish, fresh-water and occasionally subaerial deposits. They are only found in the Isle of Wight, and on the contiguous main-land, and the newest beds have the most circumscribed area. The fauna and flora are tropical, but show a gradually decreasing temperature. The highest bed, which is marine, is limited to a single hill, and contains a strangely dwarfed and impoverished, but purely Eocene marine molluscan fauna. It is thought, nevertheless, by many to be contemporary with European Miocenes. The divisions, purely arbitrary, are:—*Lower, Middle, and Upper Headon, Osborne and St. Helens, Bembridge Limestone, Bembridge Marl, Hempstead* fresh water and marine. The marine beds are relatively most developed in the east, the fresh-water in the west of the island.

Having thus glanced at the salient features of the strata the Eocene in England, I will now endeavour to

interpret the changes in character of the deposits and their contents. I wish, however, to impress upon my readers that while the foregoing section of the subject is well ascertained fact, a portion of the remainder is, for the present, to be considered as mere theory and individual opinion. It has not previously been laid before men of science, and therefore, although it seems to me perfectly consistent, objections may be urged against my conclusions.

We learn from M. Hébert's writings that the whole group of Eocenes in France and Belgium, below the Thanet Sands, and of which we have no record in England, were deposited in an area alternately sea and dry land, and subject to much oscillation. In the intervals between these recurring changes of level, deposits were formed, but each change denuded them, so that only mere fragments of the original beds now remain. The deposits were formed by a gulf opening into the North Sea which itself communicated with the ocean between the Shetland Isles and Norway. This sea may have penetrated over portions of England and left deposits upon the much eroded Chalk, which denudation subsequently carried away. However this may be, there can be no doubt whatever that the Thanet Sands were littoral deposits of the same sea, and mark a period of depression in the London Basin.

I shall have to speak of the deposits of a Northern and Southern Sea. For the present it will suffice merely to suppose that the English and St. George's Channels were dry land in these remote times, and to distinguish the seas on each side of the barrier respectively as Northern and Southern. Overlying, and perhaps partly contemporaneous with, the shallow sea deposits of the *Thanet Sand* are the English mottled clays belonging to the *Woolwich and Reading Series*. In the direction in which they are deposited and thin out, we have the first evidence of the presence of a mighty river flowing from west to east and scouring and draining a granitic country. In the estuarine beds and the lignites around London, we can trace its delta and embouchure, whilst the marine sands to the east were thrown down by the Northern sea into which it poured. Throughout the whole Eocene time we shall trace the presence of this great river, which receded and advanced and changed the direction of its outfall in obedience to the continued oscillations which this part of its course experienced.

The next movement, at the close of the Woolwich and Reading series, was probably one of slight upheaval, during which the south-east of England became land. Depression followed, and the Northern Sea gradually reoccupied the tract. The shingle and sand banks of the *Oldhaven beds* mark this change, and are the result of the littoral conditions which prevailed

during the recession, but rearranged and also greatly added to by the advance of the sea. The remarkable extent to which the flints are worn shows that the duration of these conditions was very considerable, whilst the change in the fauna seems also to indicate a great lapse of time between these events. In some places rolled pebbles of the mottled clay are included, so that this must at least have been hardened by this time.

In the *London Clay* we see a further depression of the land, enabling the Northern Sea to encroach gradually from the north-east, and ultimately reach as far west as the present borders of Dorsetshire. It never attained more than a few fathoms depth in the western area, and little more than 100 fathoms in the deeper eastern parts. The marine fauna is far more *torrid* looking, owing to a warmer period having set in, produced probably by the rise of land between England and North America which, there is evidence to show, took place about this time, and shut off the cold arctic currents in a manner to be explained further on. The increased temperature of the sea acted upon the land, and enabled a most luxuriant and varied flora to migrate thither; its fruits and seeds are found at Sheppey just as they were stranded and buried in the delta-mud of the great western river.

The river, whose delta has been seen to have been hitherto in the eastern area of the London Basin, seems now to have shifted its course to the south. Its mouth at this period may have been on the since denuded Wealden area, or still further off out at sea.

The *Lower Bagshots* such as we have them at Alum Bay, Studland, Corfe, &c., show no proximity to the sea, but rather the filling in by river action, of a wide valley and shallow lake. The complexity of the stratification renders it doubtful whether two rivers did not unite in this valley, and shows plainly that the waters must in any case have been rapid at times, and subject to periodical fluctuations of volume.

As there are no passage beds or signs of any delta having existed here between the London Clay and Lower Bagshots, we must conclude that the river did not immediately occupy this part of the land left dry by the retreat of the London-Clay sea, but flowed over it long subsequently, gradually shifting its outfall from east to south and west. The great deposits of rolled flints above the London Clay in the eastern parts of the London Basin show that the North-Sea littoral occupied that area for an immense lapse of time. We see by the composition of the western fresh-water beds, that a granite area was still being worn away, and the total absence of flint shows that the western chalk hills were not yet raised into position for denudation by the river, as had they been upraised the course of the river would necessarily have been through them. The absence of lignites in this part

of the series may show the existence of lakes such as that at Bovey Tracy which intercepted drifting timber; its abundance in later beds marks the time when they had been filled in.

In the age of the *Bournemouth Beds* we have the same deposits, but in a more open and level valley, and in close proximity to the sea. In all the lower or freshwater series we have no sign of the presence of sea-water. It is, therefore, not a case of river deposits encroaching on the sea, but of land sinking so gradually as to allow the sea to cover them.

There are absolutely no indications, either in the Lower Bagshot or in the Bournemouth Beds, of the leaves having travelled from afar, and their preservation and local distribution indeed forbid the assumption that they have done so.

In the Bournemouth Beds it is of extreme interest to trace the change from a comparatively upland flora to a valley, and then a swamp flora; to watch the lowering of the land until it became sea; to trace the sea, first trickling in and forming lagoons, then boldly overwhelming their mud deposits with all the imbedded contents, and heaping over them shingle and sand; to see the actual shore line, with land deposits full of plant remains on one side of it, and the bed of the sea with teeth of sharks and rays and shells on the other side.

The elevation of the land towards the west which caused the Northern or London-Clay sea to recede was followed by a depression towards the south-east, which not only diverted the embouchure of the river in that direction, but subsequently enabled the Southern sea, then occupying part of France, to encroach upon the land, and overlap to a small extent the older deposits. In those days the North Sea was completely separated from the Bay of Biscay, neither the English nor St. George's Channels having been formed. Not only are the faunas of the two seas totally distinct, but the lithological characters of the deposits enable them everywhere to be identified.

During the whole of the Eocene period until these beds are reached, we see that the now separate Tertiary Basins of London and Hampshire were continuous, and that identical series of strata were deposited over them without any discontinuity whatever. From this time, however, it is clear, from the total absence of any of the newer Eocene deposits in the former, that a separation had taken place, and that the London basin must in some manner have been severed from the latter. The London area, or at least the ridge which now separates it, must, therefore, have been upheaved at about this time, and perhaps again depressed when the elevation of the Weald took place. It has since been subjected to denudation on a large scale, and it is estimated* that the "vertical loss in the valley of the Thames

* "Memoirs of Geological Survey," iii. 55.

is 500 feet," and that "the flat arch of the Isle of Thanet is not wholly owing to the chalk having been thrown into that form, as at least 600 feet of other formations have been denuded off that tract."

The depression during the *Bracklesham period* was prolonged into that of the *Barton Beds*, which accordingly are found to indicate deeper seas. A remarkable change in the fauna almost suddenly takes place. We have an influx of mollusca of a comparatively temperate aspect, recalling strongly those of the London Clay, and a migration of the more tropical of the Bracklesham forms, only 25 per cent. of the less tropical remaining and mingling with the new fauna. This seems to point to the mingling of the waters of the North and South Seas, and the submergence or destruction of the dividing isthmus, which we know to have been extremely narrow, since deposits of the older seas actually overlapped each other in the Isle of Wight. The succeeding sands belong to the same period, and, as already remarked, do not necessarily indicate change.

After this the seas were again severed, and remained so until recent times, the English Channel, there is reason to believe, having been indeed formed during the human period.

It is interesting to find that Mr. Sorby, now President of the Geological Society, inferred on totally independent grounds—the study of evidence of wave and ripple action in the marine and estuarine beds of the Isle of Wight—that a great river ran from the west into the sea, its estuary including part or the whole of the present Isle of Wight, and that the breadth of its estuary was there 15 or 20 miles. "Yet the dimensions of the river were such as to keep the water in general more or less fresh, and must have been much greater than any now running in England." He was able to trace the approximate size and direction of the shoals, and the axis for the rise and fall of the tides, the direction of the freshwater currents and prevailing winds, at least those which acted with most force upon the sea. This confirmation is of value.

The whole of the vast fluvio-marine or upper Eocene series, 100 feet more in vertical thickness than the height of St. Paul's, presents us with the section of a great river delta formed in an area of depression, similar, perhaps, to that of the Nile or Ganges. Each successive deposit seems to have been thrown down over a more and more circumscribed area, and by a diminishing volume of water. The lowest or Headon Beds alone can be traced across to the main land; whilst the highest Hempstead Beds are almost confined to a single hill. These enormous accumulations present us with an unbroken series of events in one spot, extending from the middle Eocene to the Miocene age in Europe. During ›se of time we see constant changes and modifications taking

place in the mollusca. Over and over again fresh species of Cerithiadæ, Limnæidæ, Melaniadæ, and other estuarine shells, come in and disappear again. During this period, too, we not only have evidence of the diminution of the volume of the river, but also of a gradual lowering of the temperature, and a more and more wide departure from the tropical conditions which prevailed during the middle Eocene and to the close of the Headon period.

From the close of the Hempstead period until the river finally became lost, its delta or embouchure must have lain in the Solent Channel or in the sea beyond.

The truly marine mollusca of the highest Hempstead bed appear so impoverished and present such a paucity of species and these so stunted, that, coupled with the nature and limited area of the deposit, we must conclude that they were formed in a sea which had shrunk to a mere salt or brackish lake without communication with the open sea beyond. That it was com pletely isolated is certain, since there is no incoming of the Miocene marine forms which existed abundantly elsewhere. The forms are characteristically Eocene, but, except such as the *Corbula* which were enabled to withstand the influx of fresh water, of a degraded type. We have no evidence of the Hampshire Basin again becoming submerged; and although there are abundant indications of larger rivers than those at present existing having flowed through the district even in human times, how far or whether they were in any way connected with the great waters whose history I have endeavoured to trace is very doubtful. Nor have the oscillations which produced these frequent changes of level and at a later period upheaved the Chalk altogether ceased, as there is abundant evidence in the Isle of Wight and on adjacent coasts of elevation and subsidence even within historic times.

Throughout the whole of our Eocene the river action may be more or less distinctly traced, and whether we examine the structure of the rocks themselves or the fossils they contain, the conclusion is irresistibly forced upon us that for countless ages the mouth of a great river occupied at first the south-east and then the south of what is now England; and that during the whole period its delta was subject to change of level, becoming more or less depressed, as we see in recent deltas, permitting now the sea to invade it, now the deposits to rise above water and become inhabited by plants and animals.

Having now shown the existence for countless ages of a river of far greater magnitude than any which the drainage of our present England could furnish, we will briefly consider the probable extent and position of the western land surface from which it flowed.

We are all familiar with that favourite speculation among geologists as to the existence of the former continent of Atlantis. Geologists, zoologists, and botanists have frequently discussed the question; and each time, as fresh discoveries and information have been brought to bear, with more and more weight. The discovery that throughout the whole Eocene period a vast river flowed from the westward, from an area which would now support but comparatively small streams, together with the multitude and variety of the flora and fauna brought down by it, and the former total severance of the North Sea from the Bay of Biscay, reduce from theory to fact, and in the most positive manner, the assumption that a great extension of land then existed to the west of Cornwall. The extraordinary mingling of American, Asiatic, Australian, and African genera in all European floras of Tertiary periods shows no less conclusively that some communication existed between these several lands in former times. In the main, however, I believe the great area of the Atlantic to have been ocean ever since Cretaceous times. We have, in all the Eocene deposits, evidence only of littoral and shallow seas; the Eocene oceanic deposits are unknown, and if ever brought to the surface have again sunk. It is more than probable that most of what was then ocean is, in the main, ocean now; and that vast deposits, similar in extent to the Chalk and older rocks, have been, and are now, uninterruptedly forming. While, however, the wider extent, and perhaps the greater depths, have remained ocean, it is certain that at least the areas contiguous to both America and Europe have been land at no distant date. The contour map of the "Challenger" and other soundings reveal the presence of a great ridge less than 1,000 fathoms deep, running in a zig-zag direction north and south, coming to the surface at the Azores, St. Paul's Rocks, at Ascension, and at Tristan d'Acunha; and soundings taken by the United States sloop "Gettysburg" tend to show that the island of Madeira is also connected with this ridge. An elevation of less than 1,000 fathoms would unite England and Ireland, and extend the land far to the west, 10 degrees beyond Cornwall, producing a surface sufficient to account for all the results we see. An elevation of 2,000 fathoms would give us a continent whose outline can be traced, with elevations 12,000 feet high, and a ridge with a mean height of 6,000 feet, stretching across the equator. If we suppose the depths of the Atlantic on each side of the ridge to have been dry land and former valleys, and there is no inherent impossibility in this supposition, the ridge itself would have an elevation of 15,000 feet, whilst the Ascension, St. Paul, and other peaks would tower to a height of 30,000 feet. We should thus have of mountains above the snow level stretching from an

Australian land across the equator, and forming bridges by which the most temperate plants might have migrated from Australia and from America without being killed by heat. Even with the supposed elevation of 2,000 fathoms the ridge would have been sufficiently elevated to permit the passage of all the plants yet found in Tertiary beds. Without pursuing the subject further, the fact remains that at all events a great tract of land existed where sea is now, and that Cornwall, the Scilly and Channel Isles, Ireland, and Brittany, are the remains of its elevated land. It must, at least, have been as large as France, Switzerland, and Germany, although unconnected with southern Europe. There is, in addition, an ever-increasing mass of botanical and zoological evidence showing that the Atlantic Isles formerly must have been portions of a great continent; and Wollaston, from a study of the insects of the Azores, Madeira, &c., quite recently has been able emphatically to reiterate this fact.

It is probable that throughout the whole of the Eocene period this land was slowly sinking, and opinion has gained ground that the former connection with Australia and Africa became severed during that time. The great submergence, however, did not take place until Miocene times, and was coincident with the elevation of the Alps. The upheaval of the Alps was doubtless directly connected with the sinking of a correspondingly great area, and the magnitude of the subsidence may yet be ascertained by the mass of the elevation. While the London Clay was accumulating, the sea still rolled over some of the loftiest summits of the Alps, and the changes that have subsequently occurred equal in amount the conversion of sea into a continent as large and lofty as that of Europe, Asia, and the north of Africa, and of land into sea to at least an equal extent. "The grand sinking down of the conglomerate of the molasse more than a mile vertically did not begin till all the Eocene movements had terminated, and the upheaval of the same molasse took place at a later period, so that it reached at length its present altitude of 3,000 and 4,000 feet above the sea." * In face of these stupendous movements, the oscillations, whose effects we have endeavoured to trace in England, appear insignificant, the total sum of the depression in Eocene times not exceeding 1,800 feet. Our Eocene area, however, was but the border land, the axis between elevation and subsidence, and, although continually shaken, participated decidedly in neither movement, each tendency being constantly checked.

Vast as must have been the lapse of time during the accumulation of our some 2,000 feet of Eocene strata, still greater appears the interval, of which we have no record in Europe, between the Chalk and Eocene. The almost complete change

* Lyell, "Annual Address to the Geological Society," 1850.

in the fauna and flora, and the utter want of connection between any of the Cretaceous and Tertiary phenomena as seen in England, speak of an almost inconceivable and perfectly immeasurable hiatus. Of the supposed passage beds in Europe many are Eocene, but I believe that in America the gap is at least partly filled up by the Dakota and overlying so-called Cretaceous strata. The true age of these, possessing a molluscan fauna and a flora of strangely Eocene aspect, mingled with Ammonites, Baculites, *Inocerami*, and Dinosaurians, is far older than our Eocene, but certainly newer than our Chalk. My own belief has always been that they are of transition age, and fill up one of the greatest of the geological gaps. The Chalk from its oceanic nature must formerly have been of immense extent, and the patches still extending over wide areas are but relics of it. Throughout ages preceding the Eocene time and ever since until the present day it has been incessantly worn and denuded, to what extent we imperfectly see in the enormous beds of shingle and sand in the Eocenes, Pliocenes, and Pleistocenes, and in the gravels of the present sea bed.

REVIEWS.

MR. PROCTOR'S WORKS.*

ANY subject on which Mr. Proctor undertakes to write is sure to be treated in an eminently lucid and concise manner. Indeed the popularity of his printed works, and of his admirable scientific lectures, affords sufficient evidence that the fact is fully and widely appreciated. Setting apart the "Star Atlas" as more topographical in character than literary, but which, already in its fourth edition, is perhaps the most convenient guide for the amateur star-gazer as yet published, all the works enumerated below, with one exception, have run through two or more editions.

"The Plurality of Worlds," of which the fourth reprint has lately appeared, originally propounded views differing from those usually accepted, these being based on the signs of systematic aggregation among the lucid stars, and of a more intimate association of those stars with the Milky Way than could be expected were Sir W. Herschel's fundamental theory correct. In the last edition, besides other modifications, three important discoveries, that namely of oxygen in the sun, of the fading of the new star in Cygnus into a planetary nebula, and of the two moons of Mars, have been incorporated as "supplying new and strong arguments in favour of the theory of cosmic evolution advanced."

The third edition of the "Transits of Venus" has been enriched with the results of the British Expedition, which if not altogether so satisfactory as could be wished, so far at least as their separate examination is concerned, serve at least to dispose finally of all doubt on the questions which were discussed before the transit of December 9, 1874. The memorable controversy on this subject will be in everyone's recollection, and probably Mr. Proctor is correct in stating that "it is altogether unlikely that any

* "Other Worlds than Ours: The plurality of worlds studied under the light of recent researches." Fourth Edition. "A New Star Atlas." Fourth Edition, folio. "Transits of Venus: A popular account of past and coming transits from A.D. 1639 to A.D. 2012." Third Edition, to which is added a note on the results obtained by the British Expedition. "The Universe of Stars: Presenting researches and new views respecting the constitution of the Heavens." Second Edition. "A Treatise on the Cycloid and all forms of Cycloidal Curves, &c." By R. A. Proctor, B.A., Scholar of St. John's Coll., Cambridge, Mathematical Scholar and Hon. Fellow of King's College, London. 8vo. London: Longmans, 1878.

attempt will be made hereafter to make Delisle's method the basis of any systematic series of transit operations."

"The Universe of Stars," now in its second edition, is dedicated to Adams and Leverrier, and aims at establishing a new theory of the universe, by which, "instead of separating the stars and nebulæ into distinct systems, or rather of looking on the stellar system as a member of the system of nebulæ, we seem compelled to look on almost every object visible even in the most powerful telescope as a portion of one system, which comprises within its range single, multiple, and clustering stars, irresolvable nebulæ, gaseous bodies of symmetrical and unsymmetrical figure, and in all probability myriads of other forms of matter as yet undetected." It gives an accurate account of the results obtained by Sir W. Herschel during his long and arduous labours in the study of the star-depths. The conclusions arrived at are briefly that "the sidereal system is altogether more complicated, more varied in structure, than has hitherto been supposed. Within one and the same region coexist stars of many orders of real magnitude, the greatest being thousands of times larger than the least. All the nebulæ hitherto discovered, whether gaseous or stellar, irregular, planetary, ring-formed, or elliptic, exist within the limits of the sidereal system. They all form part and parcel of that wonderful system whose nearer and brighter parts constitute the glory of our nocturnal heavens." It is impossible, with a theme like this, for a thoughtful mind not to be led on to much grand and far-reaching speculation. In the presence of the Three that bear witness to man's puniness, Matter, Space, and Motion, once more the cry goes up to heaven so well formulated by Newton, as of a child picking up pebbles of knowledge on the sea-shore, while the great ocean of truth lies all undiscovered before him. In this book it takes the form of a quotation from Jean Paul which singularly reproduces a kindred dream of the boldest and most imaginative thinker of antiquity, namely the myth of the Whorls at the end of Plato's "Republic."

The "Treatise on Cycloids and Cycloidal Curves" stands on a somewhat different footing from the works above named. Whereas they are speculative and theoretical, this is precise and constructive. It deals primarily with the geometry of cycloids, curves traced out by a point in a circle rolling on a straight line, or on or within another circle, and trochoids, traced out by a point within or without a circle so rolling.

The cycloid, long known to ancient astronomers, was first fully investigated by Galileo. By suitably selecting radii and velocities, every form of epicyclic curve can be obtained, including the epicycloid and the hypocycloid. When the radius of the fixed circle is indefinitely enlarged, or in other words, when the centre of the moving circle advances uniformly in a straight line, the curve traced out by the moving point becomes a trochoid, and may either be *prolate*, *right*, or *curtate*, according as the velocity of the moving centre is greater, equal to, or less than the velocity of the point around that centre. Lastly, if the radius of the moving circle is indefinitely enlarged, so that a straight line is carried uniformly round a centre while a point travels uniformly along the line, the curve traced out becomes a spiral of the family to which belong the spiral of Archimedes and the involute of the circle.

Ancient geometers were not very successful in investigating these curves. "Even Galileo was reduced to the necessity of weighing paper figures of the

curve in order to determine its area. Pascal seems to have regarded their relations as of sufficient difficulty to be offered to the mathematicians of mathematicians to try whether a power with that of the study of mathematics was not a match for mathematicians of their own [illegible].

The book itself is divided into [illegible] with the right cycloid, the epicycloid and hypocycloid, [illegible] with an appendix or elliptical hypocycloids, the theorem the spiral of Archimedes, and the spiral track of a planet [illegible] cycloidal curves, epicycles, [illegible] use of cycloidal curves to determine the [illegible] of matter projected from the sun.

Regarding the treatment of these different [illegible] the space of a notice such as this to give more than a few general indications, although the writer, contrary to the supposed practice [illegible] having read with interest the [illegible] title-page to colophon.

In the first place it is a refreshing study in geometry as opposed to analysis. There are many minds, especially those of the [illegible] which the former gives more objective reality than the latter, and there are others to whom deltas and sigmas are a sealed language, but who can readily always puzzle out a construction and the [illegible]. Secondly, the subject, somewhat apart from [illegible] interesting matter, and touches a practical point more often than at first appears. Examples of this are [illegible] and its base is three times that of the generating circle, that the evolute of the cycloid is an equal cycloid—referred to fully in a later chapter—a property utilized in Huygheus's [illegible] for producing isochronism in pendulums; that the hypocycloid becomes a straight line when the diameter of the rolling circle is equal to the radius of the fixed circle, as seen in "sun and planet wheel" mechanism; the description of the cardioid or epicycloid traced by a point in the circumference of a circle rolling on an equal circle; of the involute of a circle regarded as an epicycloid whose generating circle has infinite radius; that the hypocycloid becomes an ellipse when the diameter of the rolling circle is equal to the radius of the fixed; the few lines about the trisectrix, and its manner of solving the much vexed problem of the trisection of an angle, and the proof of the identity of the epitrochoid with the spiral of Archimedes.

The comments on planetary and lunar epicycles, with two beautiful plates in illustration, deserve special mention; as also do those on which Lescarbault's observations of the supposed intra-Mercurial planet Vulcan turned. The note on Mr. Perigal's geometric chuck, by which many of the illustrations have been furnished, will recall an old friend to many readers. The companion to the cycloid, better known as Roberval's "curve of sines," has the deepest interest to students of acoustics, vibration, or simple harmonic motion in any form; and the graphical use of the cycloid opens a comparatively fresh field of labour.

Speaking generally, the writer has derived so much pleasure from a perusal of this little book that he confidently recommends it to his brother students. Mr. Proctor would confer a boon on many mechanics and physicists if he

were to supplement this volume by undertaking a simple description of other higher curves now but little known and concealed under mystical titles such as "the Witch," with methods for their continuous instrumental tracing where possible, and a geometrical delineation of their properties.

W. H. STONE.

THE SYSTEM OF THE WORLD.*

NEWTON stated the first law of motion in the following words: "Corpus omne perseverare in statu suo quiescendi vel movendi uniformiter in directum." And since his time it has been universally accepted that inertia was equally applicable to uniform unretarded motion in a straight line as to a state of rest.

Mr. Jordan, however, states in his first lecture that "the latter half of the definition of *vis inertiæ* is, without the slightest fear of anyone in this room rising to contradict what I say, a mere fiction. It is a fiction, and has always been a fiction. It is a fiction invented to explain phenomena for which no other explanation had been found; no practical evidence of its existence can be given in any physical phenomena."

It is sincerely to be hoped that the writer of this passage will not try the dangerous, though perfectly conclusive experiment, of jumping out of a railway train when in motion. He might obtain unpleasant "practical evidence of its existence."

In place of this "fiction" he seems to substitute what he terms "astral gravitation." This new force he holds to be demonstrated by Dr. Wallich's discovery of animal life at the bottom of the sea, and Mr. Rainey's experiments as to molecular motions of small particles in hermetically sealed globes of water.

The writer of the present notice is well acquainted with these laborious and remarkable observations of Mr. Rainey, but has always regretted that their author should have attributed the really existent currents to so novel and unheard-of a cause as "an alteration in the centre of gravity of the earth." Such a phenomenon, if existent, would surely be known to astronomers, and would probably appear in the Nautical Almanac.

The lecturer then proceeds to describe and explain ocean-currents, of which a good map is appended, on his own hypothesis; especially controverting Dr. Carpenter's views on the subject, and the usual temperature theory.

In a second lecture, after adverting to "the fickleness of common sense," the trade-winds are referred to "astral gravitation," as are also ocean currents "analogous to the trade-winds." Dr. Carpenter and Sir Wyville Thomson are stated to have "strangely mistaken sloppy mud for living flesh in the form of Bathybius," and thus to have "made the greatest mistake that has ever been recorded in the annals of science."

The "new theory of vis inertiæ" is next applied to the tides, and

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* "The System of the World. Challenge Lectures. Winds, Ocean Currents, and Tides, and what they tell of the system of the world, &c.," by William Leighton Jordan, F.R.G.S. Second Edition. Hardwicke. 1877.

"Captain Evans, Hydrographer to Her Majesty," is told that "considering the trouble I have taken year after year to induce him to give some attention to the subject, and that now he tells me that he has not been influenced by my writings, I think it is his duty to state what is the cosmical cause, if not that indicated by the theory of vis inertiæ." The said theory is then applied to the correction of Kepler's law, and to demonstrate the falsity of the "linea recta" axiom in Newton's law. "This I claim to have done," says our author. "I have proved it false by showing the new theory of vis inertiæ, which is incompatible with that so-called axiom, to be true."

After each lecture, which seems to have elicited "loud applause," cries of "hear, hear," and occasionally of "Shame! No, no," "members or ex-members of the Council of the Royal Society and the scientific staff of the Challenger Expedition" were "specially invited to discuss what was said by the lecturer."

This they strangely and unaccountably neglected to do. Perhaps it would be best to follow their example.

W. H. Stone.

LLOYD'S PHYSICAL PAPERS.*

AN honoured name in the annals of science is that of Humphrey Lloyd; none the less so because it takes back the younger votaries of science to an almost prehistoric period. "There were giants in those days," and it is subject for sincere joy and heartfelt congratulation that one or two still survive, not only in physical but in intellectual vigour.

Malus, Fresnel, Baden-Powell, Wheatstone, Barlow, and Pereira have passed away, not without leaving their mark on physical science; and the links which connect them with modern acquisitions are well represented in the present volume. Indeed it is no small service conferred on science when a veteran in the army that makes war upon nature condescends to collect for his subalterns and juniors a record of his fights. Each paper in this book is like a clasp on the medal of "a Peninsular." "Orthes, Nivelles, Badajoz, Torres Vedras," bear no distant relation to "Report on the Present State of Physical Optics," 1834; "Observations of the Direction and Intensity of the Terrestrial Magnetic Force in Ireland;" "On the Determination of the Horizontal Intensity of the Earth's Magnetic Force in absolute measure;" "Notes on the Meteorology of Ireland" and "On the Rise and Progress of Mechanical Philosophy: Introductory Lecture delivered in the Philosophy School of Trinity College in Hilary Term, 1834."

The great defect of physics as a study is the difficulty of knowing what has been done before. Hence immense waste of work in reinvestigation and rediscovery. "The older writers on physics were sad plagiarists of our new discoveries," saith the genial and patient teacher of physics at much-abused South Kensington. But with more retrospective compilations like this and the similar work of Sir William Thomson, many a wasted hour might be

* "Miscellaneous Papers connected with Physical Science." By Humphrey Lloyd, D.D., D.C.L., Provost of Trinity College Dublin, formerly Professor of Natural Philosophy in the University. Reprinted from several Reports and Transactions. London: Longmans. 1877.

saved, many a disappointment might be averted, and many an error in the profit and loss account of science on ground of double entry might be remedied.

FLOWERS.*

IN Botany, as in Zoology, since the publication of Mr. Darwin's "Origin of Species" an entirely new start has been made. The influence exerted by this and the other works of that distinguished naturalist does not depend in the very least upon the acceptance or non-acceptance of his peculiar theory, or indeed of the doctrine of evolution in any form; it is founded upon the fact that the mere raising of the question by a voice so powerful, opened up perfectly new lines of investigation for the naturalist, and drove him perforce to the consideration of those interpretations of organic beings as living things, which there was great danger might be lost sight of under the teachings of the purely anatomical and analytical school of naturalists that was rapidly gaining the upper hand. Mr. Darwin's works, whatever might be their intrinsic merits or demerits, certainly had this beneficial effect—they drove naturalists to the study of organisms in nature, of their mutual relations and influence on each other; they gave a new and striking significance to the facts of geographical distribution, and invested the facts of palæontology with an interest which they never before possessed. Naturally also the old teleological view, according to which, as a general rule, natural objects were looked at chiefly as they affected ourselves, speedily fell into disrepute, and a grander and far more healthy philosophy of nature was insinuated into the minds of men. We began to realize that animals and plants might, perhaps, exist for themselves and for each other without reference to the convenience or enjoyment of the "Lords of the Creation," and as this notion gained ground, a multitude of harmonies, before unsuspected, were rapidly brought to light.

Nowhere have the consequences of the new methods of study been more striking than in the domain of flowers. A multitude of flowers which seemed to ordinary observers mere meaningless *bizarreries*, and puzzled the botanist by their peculiarities of structure, were found, as in the case of the orchids, to have a very serious significance, and their interpretation led indirectly to a comprehension of an immense number of other instances of apparent anomalies in floral structure, which were now seen to have a deep meaning and to be in accordance with a very general law. All these observations, by guiding to an appreciation of the influence exercised by insects upon the fertilization of flowers, opened a fresh field of research as to the purpose in nature of the bright colours and the odours of flowers, and led to the investigation of a host of phenomena which had previously attracted little attention.

It is not our purpose, nor is it within our power in the space at our command, to attempt giving even a rough sketch of the infinity of points of interest connected with flowers and flowering plants of which the new

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* "Flowers; their Origin, Shapes, Perfumes, and Colour." By J. E. Taylor, Ph.D., F.L.S., F.G.S. Small 8vo. London: Hardwicke & Bogue. 1878.

philosophy of natural history has opened a prospect, and which Dr. Taylor, in the little book before us, has very successfully discussed. Here the reader will find explained, and in a pleasant and popular style, all the points to which we have merely alluded above, and a good many more, the book being in fact a brief treatise on flowering plants in themselves and in their relations to the outside world. The geographical distribution of plants not unnaturally occupies a prominent position, and in connexion with this their geological history is of importance, besides leading to certain curious speculations with regard to the relations prevailing in past time between insects and plants. The remarkable results of the investigations of Mr. Darwin and others upon the orchids and upon dimorphic and trimorphic plants are given in considerable detail—in fact the whole subject is well treated, and the author may certainly congratulate himself on having fulfilled the design with which he set out, namely, "to place before that portion of the intelligent public who have the desire, but neither the time nor the opportunity, to make themselves acquainted with natural science, the charming and suggestive results of modern botanical investigation." It is, indeed, for its suggestiveness, in addition to the vast amount of information collected in its pages, that we should specially recommend Dr. Taylor's little book; it will probably suggest to many members of "the intelligent public" who *fancy* that they have no time or opportunity for natural-history studies, that after all here are paths indicated which may lead them to a keener appreciation of nature, and of the system of nature, by means of personal observation, without making any very serious inroads upon their time; and the book is so many-sided that all fancies may be hit by it.

The little volume is illustrated with eight coloured plates of common flowers, each containing four figures, and with a great number of very good wood engravings scattered through the text.

FERNS.*

WE are told by an excellent authority, of a certain Peter Bell, that

> "A primrose by the river's brim
> A yellow primrose was to him,
> And it was nothing more."

His opinion of ferns would probably have been of a still more disparaging nature; and we are afraid that in this respect there are a good many Peter Bells in the world. It is, so far as we know, the main object of Mr. F. G. Heath's literary activity to convert these benighted individuals to what, with all the zeal of a missionary to the heathen, he regards implicitly as the true faith, namely, a belief that his favourite ferns are among the most beautiful of plants; and truly those who are familiar with them will hardly be inclined to gainsay this opinion. In their graceful curves, in the delicate tracery of their fronds, in the beautiful effects of colour and of light and shade which they present, none of the lowlier growing plants come near them; and it is

* "The Fern Paradise, a Plea for the Culture of Ferns." By Francis George Heath. Fourth Edition. 8vo. London: Sampson Low & Co. 1878.

probably owing chiefly to their want of flowers that they are indebted for that amount of non-appreciation which they certainly do meet with.

Certainly the ferns are fortunate in their present advocate. Mr. Heath writes about them with a knowledge derived from years of study, and with an enthusiasm which ought to carry his readers with him. In his "Fern Paradise," a fourth copiously illustrated edition of which has just appeared, his descriptions of ferny scenery, especially in Devonshire, the land of ferns, suffice to inspire the reader with a longing desire to join in the shady walks and pleasant rambles which are so vividly presented to his imagination, and gain infinitely by their contrast with the brick walls and glaring pavements among which it is the fate of so many of us to pass the greater part of our lives. This portion of Mr. Heath's book is beautifully illustrated with numerous photographic views of the scenery described, reproduced by the Woodbury process. These views have been selected with the eye of an artist.

Mr. Heath's task does not end here, however. The missionary's business would be but lamely performed if he merely convinced his converts of the existence of Paradise without teaching them how to get there; and our author's mission would be equally unfulfilled if he stopped short at merely convincing his reader's mind that ferns are very beautiful things. Mr. Heath's conviction is that the contemplation of the beautiful forms and delicate colours of ferns, the taking an interest in them and learning something about them, cannot but have a refining and improving influence upon the mind, and that the cultivation of ferns may in this way be most beneficial. He further shows that this cultivation may be very easily effected, so that those to whom a country ramble comes like a brief ray of sunshine in an otherwise clouded existence may surround themselves at home with the beautiful feathery forms of these children of the woods and green lanes. Some of them may be grown in almost any scrap of garden, in houses, windows, yards, and even in the areas of city dwellings. Lace and jewels, fine furniture, pictures, statues, and vases, are all beautiful things, but to get them is the lot of but few; the "Fern Paradise," on the contrary, may be realized by almost everyone and in almost any situation. As a guide to such of his readers as may desire to put his teachings to practical use, Mr. Heath gives a series of descriptions of British ferns, free as far as possible from scientific technicalities, and accompanied by statements as to the habits and needs of the various species. This section of the book will be very useful to the beginner, whose determinations of the species will be materially facilitated by the figures, showing the ferns in white upon a black ground, with which it is illustrated.

While we cannot go quite so far as our author in his belief in the ameliorating influences of fern-culture, we can sympathize with him in his desire to see these beautiful plants more generally cultivated. The mere tending of them and watching their growth must be a source of pure pleasure to those who can be induced to take an interest in them; the contemplation of their beautiful forms and delicate colour must also be a source of gratification; and unquestionably the influence of such pleasures upon the mind must be beneficial, even independently of any knowledge of natural phenomena which may be picked up by the way. We can recommend Mr. Heath's

book as one that will be read with much interest, and in conclusion can only express our gratification that its success has already been such as to warrant his expanding his original little volume to its present form, in which it is what our French friends would call a veritable *ouvrage de luxe*.

NICHOLSON'S MANUAL OF ZOOLOGY.*

WE have much pleasure in calling attention to the publication of a fifth edition of this excellent manual. It is, perhaps, the best exponent of modern non-Haeckelian views on zoological classification that we possess in English; and in the present edition, which is considerably enlarged, the author has been enabled to insert a good many more details as to the habits of animals and their relations to each other than were to be found in former issues, which might be regarded rather as giving the dry bones of animal morphology, than as expositions of the science of animals as they "live and move and have their being." Much room for improvement in this respect no doubt still remains, but unless the book could be at least doubled in size, it would hardly be possible to give a satisfactory zoology embracing as much of structural detail as the present work. As a manual for students, which is what it professes to be, Professor Nicholson's book is exceedingly good.

This fifth edition does not differ in any important particulars from its predecessors, as regards the general treatment of the subject. The classification adopted is the same, with some slight exceptions, where groups of recent establishment have been accepted; but the treatment is much fuller, and the results of very recent researches have been worked in, the additions being even more extensive than would appear from the increased number of pages, seeing that the author has adopted the device of printing a good deal of matter of subordinate importance in small-type paragraphs.

Another new feature in the book is the suppression of the synoptical tables of families which appeared in former editions and the substitution for them of class bibliographies, which, if in some instances rather defective, will nevertheless prove useful to the student by indicating the main directions in which his further studies may be profitably pursued. This edition, which has many new illustrations, worthily maintains the reputation acquired by its predecessors.

THE MAMMOTH AND MAN.†

THE object of the writer is to prove that there are no traces of Man having existed before or during the so-called Glacial Period—that this Period occurred at no considerable distance of time ago—and that Man was intro-

* "A Manual of Zoology for the Use of Students, with a General Introduction on the Principles of Zoology." By Henry Alleyne Nicholson, M.D., D.Sc., M.A., Ph.D., F.R.S.E., F.G.S. Fifth Edition. 8vo. Edinburgh and London: Blackwood & Sons. 1878.

† "The Epoch of the Mammoth and the Apparition of Man upon the Earth." By J. C. Southall, A.M., LL.D. With Illustrations. 8vo. Trübner & Co., London: 1878.

duced recently, since that Period, in the fulness of his development. Dr. Southall avows his desire to treat of *facts* in discussing the question of Man's age on the earth; but he has apparently a very limited view of many of the facts he refers to, and certainly uses them only as data for special pleading.

The style of argument adopted can be thus illustrated. No human remains have been found in Miocene or Pliocene strata, *ergo*, Man never existed in Tertiary times! High civilization obtained in the earliest known times of Egyptian and Babylonian history, *ergo*, there was never a purely Stone Age in Egypt and Chaldea! Cain *built a city*, *ergo*, the earliest men were architects! Chaldeans and Egyptians appear to Dr. Southall to have come abruptly on the scene in a civilized condition some 6,000 or 10,000 years ago, *ergo*, Palæolithic Man can claim no higher antiquity; hence, too, there was no *evolution* as far as the human race is concerned! Further, many beliefs, customs, and modes of worship are, or have been, common to widely separate nations, *ergo*, mankind came at once, Egyptian, Hindoo, Babylonian, the "fossil man of Mentone," the Neanderthal savage, and men of the Somme Valley, and not more than 10,000 years ago! Errors have been made by antiquaries and others in estimating the age of antiquities, fossil bones, marks on bones, and of natural and artificial accumulations, *ergo*, there is no acceptable evidence of high antiquity for man!

Megalithic Monuments, Lake-dwellings, Danish Shell-mounds, Peat-deposits, Bone-caves, and River-gravels, are all regarded as having led both original and subsequent observers over treacherous grounds into fallacious reasonings, which our author thinks himself competent to make good! Because there are comparatively recent stone-implements, pile-dwellings, refuse-heaps, and peat-beds, none can be credited with a high antiquity! Because floods can shift gravel and other débris, a grand pluvial flood must have followed the Glacial period and arranged the valley-gravels of Western Europe! Because Assyrian kings hunted the Asiatic elephant, therefore the *Elephas primigenius* of Northern Europe, or Siberian Mammoth, carries no evidence of high antiquity! Oscillations of land and sea are allowed to have taken place on a grand scale; but, as one of the evidences "that *force* as well as *time* is an element in geological action," the long-exploded mistake about Jorullo is reproduced; and the volcanic phenomena of Miocene and Pliocene times are brought in as "recent geological convulsions"; but how they fall in with our author's notions of the history of man is not clear. And thus we go on reading Dr. Southall's many notes on other people's discoveries and writings, over many parts of the globe, and find that the evidences for man's great antiquity are carefully eschewed, and whatever can be brought forward to strengthen the writer's own opinion is industriously presented. When we look for a scientific treatment of such subjects as the alterations of level by oscillation and denudation—of successive depositions and removals of material—of changes in the configuration of Western Europe, where certain races of early man did exist—and of variations of climate, and consequent differences in successive faunas and floras, we have the results of imperfect and one-sided efforts to master the facts and opinions which geologists and naturalists have given to the thinking world.

THE HUMAN EYE.*

IN this little book Dr. Dudgeon furnishes his readers with an excellent popular description of the eye, and of the optical principles by which it is enabled to convey to the brain the visual impressions of external objects. The whole explanation is very clear and lucid, and the author has availed himself of all the more important recent treatises on vision published both in this country and on the Continent. Of especial interest are his observations on sub-aquatic vision, upon which he has made many personal experiments which lead him to the conclusion that perfect vision cannot be attained under water by the unassisted eye, and he accordingly recommends the use of air-spectacles, the construction of which is fully explained, in order to counteract the altered conditions of refraction which must affect vision under water.

This, however, is not the only original part of Dr. Dudgeon's little book. The question of the means by which the eye is enabled to adapt itself to vision at different distances is one which has always presented considerable difficulties, and the observed phenomena, and especially the direct observation of the form of the surfaces of the lens in near and distant vision, led the author to the conclusion that changes of convexity in that particular part of the eye were not the causes of the adaptation of the eye. Moreover the mechanism for producing them seemed to be wanting. The consideration of the phenomena presented by the surface of the lens, when the eye is directly examined under changed conditions of vision, suggested to Dr. Dudgeon another explanation, namely, a shifting of the position or twisting of the lens relatively to the axis of the eye, which, he maintains, from the form of the two surfaces of the lens, would produce the alterations of refractive power necessary to adjust the eye to changes of distance. Upon this ingenious hypothesis we shall not venture to offer an opinion, but it certainly seems worthy the attention of students. The little book is fully illustrated with woodcuts, and is a valuable contribution to our popular scientific literature.

A GEOLOGICAL MAP OF LONDON.†

THIS is Stanford's capital "Library Map of London," coloured geologically. The scale is six inches to a mile, far larger than that of any other geological map of London, the Geological Survey having published only the ordinary "one inch" map. The area embraces on the north Hampstead, Highgate, Clapton, and Leyton; on the east Stratford, Greenwich, and Lee; on the south Beckenham, Anerley, and Merton; and on the west Wimbledon, Putney, Hammersmith, and Willesden.

The compilation of the geological information has been carefully carried out by Mr. Jordan, who has great experience in such work. The map shows not only the Chalk and the various Tertiary beds, but also, to quote

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* "The Human Eye: its Optical Construction popularly Explained." By R. E. Dudgeon, M.D. Sm. 8vo. London: Hardwicke & Bogue, 1878.

† Stanford's "Geological Map of London. The geology compiled from the Maps, &c., of the Geological Survey by J. B. Jordan" London, Stanford. 1878.

from the Publishers' Circular, "the superficial deposits of gravel, &c., which, though comparatively thin, have so great an effect on the form of the surface and the nature of the soil."

The work can be had in various forms, to suit the convenience of purchasers. Each of the 24 sheets is sold separately; or the whole in a portfolio, with an index inside the cover; or mounted together as a large wall-map.

BIBLE PLANTS.*

BIBLE students have every reason to be grateful to Mr. Smith, the ex-curator of the Botanical Gardens at Kew, for the concise history of the plants mentioned in the Bible which he has just prepared for their delectation and improvement. He has devoted a considerable amount of labour to the identification of the plants and plant-products mentioned in the Scriptures, and to collecting and considering the opinions of previous writers, and in this little volume we find the results of his investigations. The whole number of plants, as he tells us, is only about 100, and those who have never paid attention to the subject will be rather surprised to find how many plants, called by familiar English names in our "Authorised Version," are anything but what they profess to be. Thus the "tares" spoken of frequently in the Bible are not the same as the wholesome and nutritive vetch which is known by that name, but a species of grass very similar in appearance to wheat or rye, but the grain of which is so poisonous that serious illness or even death has been caused by eating bread containing its flour. This explains some of the references to tares, and especially to the sowing of tares amongst an enemy's wheat. Many points of equal interest to this appear throughout the book, which is illustrated with ten characteristic plates. We recommend Mr. Smith's little volume to the attention of all interested in Bible studies, especially to those who have to do with the communication of information on scriptural matters to the young.

PHOTOGRAPHIC SPECTRA.†

THIS is an excellent work of reference, well got up, and containing thirty-eight excellent autotype plates of spectra, including an additional photograph of the solar spectrum and spark in air, compared for the purpose of showing the position of bright lines in the former assigned by Professor Draper to oxygen. Other bright lines are seen towards the green end in both spectra, which are not included in Professor Draper's photograph.

The metallic spectra were obtained by the induction spark and by means of the electric arc. The wave-lengths are taken partly from Lecoq de Boisbaudran, partly from Dr. Watt's "Index of Spectra." The photographs are printed four to a page, on uniform lengths of four inches, on prepared paper of fine nacreous surface, which would probably lend itself well to accurate measurement.

* "Bible Plants: their History, with a Review of the Opinions of Various Writers regarding their Identification." By John Smith, A.L.S. 8vo. London: Hardwicke and Bogue, 1878.

† "Photographic Spectra." One hundred and thirty-six photographs of metallic, gaseous, and other spectra, printed by the permanent autotype process with introduction, description of plates, index, &c. By J. Paul A.S. 8vo. London: Spon. 1877.

SCIENTIFIC SUMMARY.

ANTHROPOLOGY.

h American Inscribed Stones.—In a burial mound on Cook Farm avenport, Iowa, the Rev. J. Gass has found some inscribed tablets of ious shale, which, if they prove genuine, of which we must confess eems to be some doubt, will take their place among the most interest- historic pieces of human workmanship. The mound under exploration ed two grave-hollows, in one of which, at a depth of about five and a-half m the surface there were three skeletons, two of adults, with the third f a child) lying between them; with these were found copper beads and axes, besides other objects. The second grave-hollow contained some nts of skull-bones, vertebræ, &c., and the inscribed tablets above- ned. Mr. Gass describes the mode of their occurrence as follows:— wo tablets were lying close together on the hard clay, in the north- rner of the grave, about five and a-half feet from the surface of the . . . . The smaller one is engraved on one side only, and the on both sides. . . . Both were closely encircled by a single row stones. They were covered on both sides with clay, on removal of th markings were for the first time discovered. A number of frag- of the coal-slate lay in the immediate vicinity of the tablets. It also be remarked that I did not leave the mound after penetrating h the frost* until the tablets were discovered and taken from their -place with my own hands."

e tablets are described and discussed at considerable length by Dr. J. harson, whose account of them is illustrated with reproductions of raphs. Dr. Farquharson also notices the various inscribed stones have been previously found in the United States, most of which to have been, if not frauds, at any rate not genuine; the best of them of Dighton Rock near the mouth of Taunton River in Massachusetts, is a Runic inscription recording the occupation of that region by 151 nen with Thorfins, who is identified with Thorfinn Karlsefn, with saga it closely agrees.

smaller of the two tablets is called by Dr. Farquharson a "Calendar-

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he excavation was made on the 10th of January, when the ground was hard. A shell-layer traversing the mound above the graves is said to een undisturbed.

stone." It is marked with a central circle, having a radius of one inch, round which, with the same centre, are inscribed three other circles at an average distance of three-quarters of an inch. The space between the first and second circles is marked with four characters dividing it into quadrants; in the space between the third and fourth circles there are twelve characters at equal distances apart. As to the signification of these characters, Dr. Farquharson is quite in the dark; some of them have a rude resemblance to animals, and one is interpreted as representing cross-bones surmounted by a flame, but unaccompanied by the skull which is always associated with them in Maya sculptures. The Doctor suggests a zodiacal interpretation of this design, but does not seem to place much faith in it himself.

One side of the larger tablet presents us with a "sacrificial or cremation-scene," showing a number of human figures with their hands joined as forming part of a great ring round a fire, with several human bodies lying on the ground as if ready to be consigned to the flames. This is in accordance with the account long since given by La Hontan, who says:—"The savages on the Long River (Mississippi) burn their dead, reserving the bodies until there are a sufficient number to burn together, which is performed out of the village, in a place set apart for the purpose." Above the cremation-scene are three segments of large circles, forming a rainbow-like arch stretching from side to side of the stone; the space below this arch, which may be taken to represent the sky, is thickly studded with small points, and bears two circular figures one on each side, the whole no doubt intended to represent stars, sun, and moon. The spaces between the curved lines, and the space above them, are entirely covered with engraved characters, of which no one has yet discovered the nature. In all, there are ninety-eight characters, but twenty-four of these are repetitions, so that there are seventy-four distinct figures. As a whole, or even generally, they resemble no known alphabet, although, of course, it is not difficult to trace a similarity between some of the characters and those of certain alphabets.

The engraving on the other side of the large tablet is explained as a "Hunting Scene." Thirty animals are rudely represented upon it, and among them are some which Dr. Farquharson interprets as mastodons, and it must be admitted that they have a very elephantine outline, although neither the trunk nor the tusks are shown. This picture is not accompanied by any characters. It is evident that if the genuineness of these articles can be fully established their discovery opens up an entirely new view of the condition of man in America, where, hitherto, he is supposed, at any rate in primitive times, not to have advanced beyond the art of picture-writing. —(*Proceedings of the Davenport Academy of Natural Sciences*, vol. ii., part i.)

A Prehistoric Foundry at Bologna.—M. E. Desor has read to the Society of Natural Sciences of Neuchâtel, an interesting memoir upon some discoveries of prehistoric remains lately made in and near Bologna. He says the evidences of prehistoric Italian civilization lately obtained from diggings in that district (at Villanova, Bonzano, Arnoaldi, Benacci, and Luca), notwithstanding a resemblance to the true Etruscan type, have, in many respects, a definite special character ("type of Villanova"). As it was impossible not to see what a near relationship unites the art-products found about the banks of the Reno

with those of the Swiss lake-stations of the bronze-age, and with those of the Gallic of the commencement of the iron age, and as even a portion of the local differences lose in importance from the circumstance that the one series of objects was specially destined for the service of the living, and the other for the adornment of the dead, the supposition that they had a common origin was easily arrived at. Their common source was supposed either to be among the comparatively more advanced peoples of the plain of the Po, or, as no place for their production *en gros* has yet been found there, in the old seat of the Bronze-civilization at the foot of the Caucasus. About a year ago, in the middle of Bologna, near the church of St. Francis, M. Zannoni, an engineer, came upon a great earthen vessel, 4 ft. 8 in. high and 4 ft. broad at a depth of about two feet. In this there were 14,000 bronze articles of admirable workmanship, packed together as closely as possible, and all coated with the ordinary green patina. MM. Desor and Berthoud came to Bologna just when the whole contents of this vessel were exhibited in the Town Hall. Of celts there were 2,077, from rough, wedge-shaped ones to the most highly finished and engraved specimens; 2,407 fibulæ in 25 principal forms; a great number of knives of every form and size, and also in part engraved; hundreds of chisels and a good many gouges; 275 lance-heads varying greatly in length up to more than a foot, although remarkably similar in form; half-a-hundred sickles, many of them very large. Of bits for horses there were about 60, made evidently for a considerably larger race than that of the Swiss Lake-stations. There were fish-hooks, harpoons, hammers, a large anvil, a plane, and a dozen saws. Further, several hundred different bracelets, all massive, with the ends often in the shape of the heads of animals; numerous hair pins, although comparatively fewer than in Switzerland, and usually with flat heads; 50 razors with small handles; numerous ornamented plates, the pattern of which in part resembled those of Villanova; a comb; short tubular pieces with appendages like ear-drops; quadrangular plates with markings, regarded by Gozzadini as little bells. The weapons were comparatively few, and consisted of daggers, arrowheads, and swords. With all these were casting moulds both of hard bronze and of earth.

The preservation of the specimens was not quite uniform. Among the hatchets there are some quite rough, still showing the line of junction of the moulds; others worn, and others quite new. Of the fibulæ also, some are injured and others quite perfect; some have the tongue damaged or lost; in others it has been refixed with a small iron rivet, or completed by a small lamina of bronze of suitable form. If to all this we add, that fragments and waste pieces were not wanting, and were certainly intended to be melted up, there can be no doubt that we have here the indications of an establishment in which articles were cast and repaired. It was probably in time of danger, perhaps of a hostile attack, that the possessor of these numerous articles packed them so closely into the smallest possible space, without being able to recover his property, as, fortunately for us, its recent discovery proves. No doubt from such a workshop, of which, perhaps, we have by no means all the remains before us, exportation was carried on, as this would be easier than the export of pottery, even over the mountains.

Thus it would seem that we have here a source of bronze objects for Italy and perhaps also for Switzerland, but at the same time, it must be remem-

bered that the articles found show differences from those of the Swiss Lake-stations. Many objects, such as the large sickles and lance-heads, the most abundant form of fibulæ found at Bologna, the protections for the arm made of bronze wire, the elegant hollow cylinders, probably ornaments for the hair (*tutuli*), axes such as would serve for chopping wood, and large nails from six to eight inches long, are either rare or entirely wanting so far as we know north of the Alps, or, in place of them, other forms are found. On the other hand we miss, at Bologna, the large, hollow, engraved bracelets, and the round-headed hairpins of Switzerland.

The determination of the age of these remains would be important, as it must at the same time throw light on that of the Swiss lake-stations. Whether belonging to the first development of the Etruscans ("Proto-Etruscans") or to another people, the civilization of Villanova and Bologna was certainly earlier than the true great Etruscan period. Upon this question, and in what relation if any these inhabitants stood to the Mediterranean peoples who in the fourteenth century before our era made head against the Pharaohs both by land and sea, further information is much to be wished for. —(*Neues Jahrb. für Min. Geol. &c.*, 1878, Heft 3.)

ASTRONOMY.

Transit of Venus in 1874.—It would seem we may now expect a succession of new determinations of the sun's distance from observations made on this transit; for the Continental and American astronomers have still to announce their results, and from Greenwich alone we have already received several different determinations. It will be remembered that the first result announced from Greenwich made the solar parallax 8·76″, corresponding to a mean solar distance of 93,375,000 miles. The Astronomer Royal expressed the opinion that this value could not be changed by any re-examination of the observations, and that considered in its relation to other values, it should be preferred to all. "I think there will be nothing to compete with the value we have deduced," he said. We ventured at the time to express a very different opinion, namely, that this value would have to be modified largely, and that it could not compete with the estimate of about 92,300,000 deduced by Newcomb. The result has confirmed our views. All the observations have been re-examined; "different interpretations have, in a few instances, been put on the records; several observations from colonial stations have been combined; instead of using different phases in the observations (both of ingress and of egress) attempts have been made to ascertain the one phase of "contact of limbs;" the notes of a few unpractised observers have been rejected; and the result for parallax has been increased to 8·82″ or 8·83″, corresponding to a mean solar distance of 92,676,000 or 92,571,000 miles, or say to a mean distance of 92,620,000 miles. This is a long stride in the direction we predicted.

Photography in the Transit Observations.—The results from photography have been very disappointing. "The failure," says Sir George Airy, in the Greenwich report, "has arisen, perhaps, from irregularity of limb, or from [illegible] distortion, but more frequently from faintness and want of clear

definition. Many photographs, which to the eye appeared good, lost all strength and sharpness when placed under the measuring microscope. It was once remarked to me, 'you might as well try to measure the Zodiacal light.' A final result, 8·17″, was obtained from Mr. Burton's measures, and 8·08″ from Captain Tupman's." These values correspond to mean solar distances of 100,050,000 miles and 101,164,000 miles, which are of course utterly untenable.

The Transit of Mercury.—The weather on May 6 was not favourable in this country or in France. The contacts were observed at Göttingen, Josephstadt, Kiel, Antwerp, San Fernando, and Christiania. At Kiel and San Fernando a difference of time was noted between apparent and real contact; elsewhere none seems to have been noted. In the United States many important observations were made, both by American astronomers and the French Expedition. We learn that at the observatory of Dr. Henry Draper, Hastings, on the Hudson, a number of observers availed themselves of the admirable instrumental resources provided by Dr. Draper, and the weather being favourable very good results were obtained; several of the negatives taken by Dr. Draper were particularly good. Observations were made also at Washington by Professor Newcomb; and at other established astronomical observatories. The mean time of first internal contact reduced to the earth's centre was in every case earlier than the calculated time by an interval varying from 14·1 seconds at Washington to 37·7 seconds at Göttingen.

Physical Phenomena Observed at the Transit of Mercury.—The bright spot was seen by several observers, and not seen by about as many more. If those who saw it had all seen the same spot, the positive would overweigh the negative: but this was by no means the case. Some saw the spot in the middle of Mercury's disc, some saw it eccentrically situated; to some it appeared as a well defined point, to others as a misty patch; to some single, to others double. Remembering further the utter improbability, we may almost say the physical impossibility, that there could really be present on the surface of Mercury a spot bright enough to be seen under the circumstances in which a transit is observed, we cannot hesitate to regard the spot as a merely optical phenomenon. As to the ring around Mercury the case seems almost as clear, but not quite so. On any physical interpretation of a ring either dark or bright seen round Mercury, a bright arc should be distinctly visible round the part of Mercury not yet entered on the sun before first internal contact, and round the part which has passed outside the solar disc after second internal contact. Nothing of the sort seems to have been noticed on May 6. If when all the accounts, and especially those from America, have been received, this should turn out to be the case, we must reject the observations of a ring seen round the planet when on the sun, as unquestionably illusory or optical phenomena only. That this is so, is strongly suggested by the varying nature of the phenomena seen by different observers. Some saw a bright ring, others a dark one; some a broad ring round a narrow one: the bright ring was uniform as seen by some, a mere bright border to a dusky ring, as seen by others; complete as seen by most observers, incomplete as seen by one observer. On the whole, it seems tolerably certain that the ring is an entirely subjective phenomenon, and

quite certain that it is in great part subjective. On this view of the matter, some of the observations seem more worthy than the rest of special notice. [Since the above lines were written, however, news has been received from Professor Young, of Princeton, America, which seems important. He observed that the rice-grains close to the edge of Mercury seemed, if anything, lengthened radially. This was doubtless either an illusion or an accidental relation; but as, if Mercury had an atmosphere of appreciable breadth, the rice-grains would have been elongated the other way—that is, at right angles to the direction of radii of Mercury's disc—we may safely infer that the atmosphere of Mercury is of very small depth. The bright and dusky rings must then be regarded as optical illusions.]

Early Solar Photograph Showing Granules.—Dr. Rutherford, of New York, has presented to the Astronomical Society a copy on glass from a negative of the sun, made at his observatory on August 11, 1871. It represents a small portion of the sun's disc with one spot and a group of smaller ones. He calls attention to the fact that with a proper lens the granulations, rice-grains, or willow-leaves are quite clearly visible. M. Janssen was therefore mistaken when he asserted that his photographs are the only ones, and the first, which show the granulations on the sun's surface, though Dr. Rutherford admits freely the superiority of M. Janssen's recent solar photographs.

Oxygen Lines in the Sun.—Mr. Christie has made observations upon the solar spectrum near the G line, which appear to throw some degree of doubt on the supposed evidence for the existence of oxygen in the sun obtained by Dr. H. Draper. When this region was examined with high dispersion the bright lines seemed much broader than the dark ones, and did not seem softened off either edge, as might be expected if they really were bright lines, and not parts of the continuous spectrum cut out or left by dark lines. He also found certain dark lines towards the middle of each of the bright bands or spaces. This he considers renders the hypothesis that the bright bands are really bright lines still more difficult, "as one would have to assume that the oxygen lines were each double, and were only separated by a very fine sharply defined interspace." The latter inference is not valid, however, for there is no reason why dark absorption lines should not be seen on the broad bands of the spectrum of oxygen. We know even that dark lines are usually seen on the bright bands of these elements, which increase the complexity of the spectrum by widening their lines. This is caused by the absorption of the rarer and cooler vapour of these same elements, lying outside the inferior hotter vapour. This part of the evidence is in favour of the existence of bright bands, as distinguished from mere spaces between dark lines. Whether the other point may not be similarly explained,—that is, the sharply defined edges of the broad bands accounted for by the action of absorption vapours lying above the layers of oxygen giving the bright bands,—remains yet to be seen. The idea advanced by Dr. Schuster that oxygen is not probably present in the sun in both the forms whose spectra have been obtained in terrestrial experiments, seems to have very little in its favour. On the whole it does not yet appear that the very strong evidence advanced by Dr. Draper in favour of the existence of oxygen in the sun has
terially shaken. It would, however, be rash to speak at all positively
sent stage of the inquiry.

Supposed New Spot on the Moon.—The "Cologne Gazette" announces that Herr Herman J. Klein has discovered a large lunar crater of recent formation. It is situated in the large plain lying to the west of Hyginus. It presents at the time of the first quarter the appearance of a vast cavity filled with shadow, and having a diameter of about 4,400 yards. The discovery, or rather the existence of this cavity, has been confirmed by Schmidt, of Athens, and others; whether it really is a new formation remains to be seen. Nothing is shown in this space in Mr. Mädler's large map, but in Rutherford's "Photographs of the Moon" at and near the time of the first quarter, the plain is by no means so level as it might be inferred to be from Mädler's chart.

Photography at the least refrangible end of the Solar Spectrum.—Captain Abney read a preliminary paper before the Astronomical Society two years ago, upon the possibility of photographing the red end of the spectrum. He has now made considerable progress in his researches, and has laid the results before the Astronomical Society. The first photograph was one taken through three prisms of dense flint glass, placed at the angle of minimum deviation for B. The focal lengths of the collimator and camera were 18 inches and 2 feet respectively, and a condensing lens of 6 feet focus was employed to collect the light, the middle of the collimating lens alone being filled with solar rays. In front of the slit was placed a plate of orange glass to cut off the suffused blue rays, which experience had shown to be inimical to the production of good negatives, owing to the light dispersed in the prisms themselves. The impressions of bands in the ultra red are found an enormous distance below A. Roughly speaking, A corresponds to wave-lengths of 7,600 tenth-metres, and D 5,900 tenth-metres, while the photographs show bands as far below A as would correspond to wave-lengths of 10,400 tenth-metres. But this negative, remarks Captain Abney, "has no practical scientific value, as the ultra red is so tremendously compressed that the absolute wave-lengths could not be obtained from it." Using, however, a speculum-metal grating by Rutherford, having about 8,600 lines to the inch, Captain Abney was able to photograph the spectrum of the second order. With a grating of about twice as many lines to the inch, another photograph was taken, of which the Astronomer Royal for Scotland remarks that, viewing them with high magnifying power in a compound microscope long since arranged for such things, the effect was astounding. "I almost thought," he adds, "I was back again at Lisbon, viewing the sun's spectrum itself as I used to see it." This acknowledgment of the value of the photograph was peculiarly gratifying as coming from an astronomer who had paid special attention to this part of the spectrum. After describing further operations, and the methods used, which belong rather to physical than astronomical or optical matters, Captain Abney remarked in conclusion, that he hoped in a short time to reduce the expenses considerably.

Phenomena for the Quarter.—On July 25, at 9 A.M., Jupiter will be in opposition to the sun. On July 29 there will be a total eclipse of the sun not visible at Greenwich. On August 12 the moon will be partially eclipsed. The following are the epochs of the principal phenomena:—

	Mean time at Greenwich. h m	
First contact with the penumbra, Aug. 12 . .	9 22·5	P.M.
„ „ „ shadow . .	10 42·6	
Middle of the eclipse . . . Aug. 13 . .	0 8·2	A.M.
Last contact with the shadow	1 33·8	
„ „ „ penumbra	2 53·9	
Magnitude of the eclipse (Moon's diameter = 1) .	0·590	
First contact 109° from N. pt. of limb towards E. } For direct image.		
Last „ 157° „ „ towards W. }		

BOTANY.

The Grasses of Mexico.—M. Eugène Fournier has studied the Mexican grasses to such good purpose that he has raised the number of species to 638; whilst in the "Flora Mexicana" of Kunth's *Synopsis* only 88 grasses were recorded. He finds that 16 species grow under very varied conditions of life, extending from the littoral regions to the elevated plateaux. He also finds, as he had previously done in regard to the ferns, that many species grow on both slopes of the Andes. He gives the following table showing the number of species peculiar to Mexico and common to it and other regions:—

Peculiar to Mexico	376
Common to Mexico and Texas	32
„ „ „ the United States . . .	60
„ „ „ the Antilles	98
„ „ „ the Tropical region (north of Brazil and incl. Trinidad) .	102
„ „ „ the Andes	28
„ „ „ Brazil	98
„ „ „ the Argentine Republic . .	22
„ „ „ the Old World	30

The peculiar species are very numerous and include nearly all the Mexican species of the genera *Stipa*, *Aristida*, *Mecklenbergia*, *Pereilema*, *Lycurus*, *Epicampes*, *Deyeuxia*, *Trisetum*, and *Bromus*. They are related generically to the species of the Andes of South America. Fifteen genera, out of 173, belong exclusively to Mexico and eleven of these include only a single species.

Out of 262 species common to Mexico and other regions only two grow in California. East of the Rocky Mountains, Texas has 32 species; one grows in the prairie region, and the other 59 United-States species are almost confined to Florida, Georgia, and South Carolina, scarcely any occurring in Louisiana, Mississippi, or Alabama. The cause of this peculiar distribution may be found in the direction of certain winds, especially the whirlwinds noticed by M. F. F. Hébert, which, descending upon the Gulf of Mexico by the Valley of the Rio del Norte, strike the North of Florida and then sweep northwards along the eastern slope of the Alleghanies.

By their geographical distribution and botanical characters the Mexican

Gramineæ are divided very clearly into two groups—those which are peculiar to Mexico or common to it and the Andean region, or to more northern regions, are generally distinguished by the slenderness and lightness of their leaves and panicles; those which spread into the tropical region, on the contrary, are remarkable by their size and the amplitude of their organs of vegetation and of their inflorescence. The former generally inhabit dry and mountainous localities; the latter the banks of rivers, and moist places. Some of them extend from the United States to the Argentine Republic, through 70° of latitude.—(*Comptes rendus*, June 10, 1878.)

The Influence of Moisture on Vegetation.—Dr. Paul Sorauer has made some experiments with spring barley which led to the following results:—In dry air branching was greater than in moist, the mean figures standing at 2·77 and 2·37 respectively; the length of leaves was greater in moist air in the ratio of 21·37 to 21·07, but the breadth was less (6·74 to 7·33). A moist atmosphere is more favourable to length of leaf-sheath in the proportion of 9·26 to 8·18, to the growth of the principal stem as 13·5 to 11·5, and to root-development as 26·8 to 23·9. The epidermal cells of the leaves were more numerous and broader, the cells between the stomata shorter, and the stomata themselves shorter in dry air. Leaves developing in a moist atmosphere have fewer stomata per millimetre of length.—(*Bot. Zeit.* January, 1878, and *Journ. of Botany*, March 1878.)

The Fungi of the Vine.—The study of the fungi infesting the vine is one of considerable interest, not only to the scientific botanist, but also in a high degree to all interested in the cultivation of the vine. Baron G. Felix von Thümen has published an elaborate monograph upon these parasites, containing an enumeration of no less than 220 species of fungi which occur upon vines in various parts of the world. The fungi are distributed as follows upon nine species of the genus *Vitis*:—*V. vinifera*, Lin., 150; *V. Labrusca*, Lin., 54; *V. æstivalis*, Mich., 13; *V. vulpina*, Lin., 7; *V. riparia*, Mich., 3; *V. cordifolia*, Mich., 3; *V. rotundifolia*, Mich., 3; *V. caudicans*, Engelm., 1; and *V. sylvestris*, Gmel., 2. The fungi affect the leaves, fruit, stems, branches, and roots of the plants. Nineteen fungi affect the grape itself, and of these *Oïdium Tuckeri* is the most important from an economical point of view. Baron von Thümen appears to follow Fuckel in regarding it as the conidial form of *Sphærothera Castagnei*, Lév., and therefore distinct from the American *Erysiphe nectator*, Schw., which species does not seem to have been recorded since Schweinitz's time; while it is classed by Dr. Cooke, in "The *Erysiphei* of the United States" among the "species dubiæ." Baron von Thümen also considers it unconnected with a variety of *Uncinula spiralis*, B. and C., which sometimes occurs upon the grape in the United States.

Among the great number of fungi infesting the living and dead stems and branches of the vines there are many new species. Of the Hymenomycetous fungi, twenty-two species are mentioned, mostly occurring on the dead stems; these include a small agaric from the Cape of Good Hope (*Agaricus proteus*, Kalchbr.) allied to *Ag. variabilis*, P. One of the most interesting of the fungi on living vine-leaves is a new species of *Uredo* (*U. Vitis*, Thüm.), which, like *Peronospora vitis*, is of transatlantic origin.

The difference between the American and European vine-flora is very

striking, so many fungi occurring in America which have not been observed in Europe, where vine-cultivation is such an important industry, and mycologists are so much more numerous. Many of the old species of Schweinitz have never been met with here.

Cincinnobolus Cesatii, De Bary, is a curious mould which grows parasitically upon *Oïdium Tuckeri*; it appears to be common on the Continent, but has not yet been observed in this country.—(*Journ. of Botany*, May 1878.)

The Connection of Bacilli with Splenic Fever.—Dr. Cossen Ewart publishes in the "Journal of Microscopical Science," an account of some investigations which he has made upon this subject, doubt having of late been thrown upon the supposed fact that splenic fever is caused by *Bacillus anthracis*. In the spleen of a mouse which had just died of the disease after being inoculated with the plant, the *Bacilli* were found rod-shaped and motionless. In a few hours, the temperature being 30° C. (=91° F.), many of these rods began to move actively in a wriggling manner, and after continuing in this motile state for some time, they either suddenly or gradually settled down again; and then lengthened out into spore-bearing filaments. A mouse inoculated with the spores thus obtained, died in 48 hours of splenic fever. The spores are formed in a similar manner to the Chlamydospores of *Mucor*. By Koch and some other observers these spores have been described as germinating at once, and reproducing the rods, but Dr. Ewart found that this process was often preceded by the division of the spore into four sporules, all of which closely adhere at first, but ultimately become free and settle down in colonies. The sporules then germinate and produce the rods. The most important morphological conclusion which Dr. Ewart draws from these and other observations is that the *Micrococcus*-, *Bacterium*- and *Bacillus*-forms, and the spore-bearing hyphæ are phases of the same life-history. His experiments have been confirmed by other observers. It would be unwise to push the suggested analogy between *Bacillus* and *Mucor* too far, since the true *Mucor* is a member of the most highly organized group of fungi and *Bacillus* undoubtedly belongs to the lowest.—(*Academy*, June 22, 1878.)

Studies on the Mucorineæ.—M. Van Tieghem's third memoir on these plants ("Ann. des Sci. Nat. Bot.," sér. vi. tome iv.) contains valuable observations on some points of interest in connexion with the group. He first deals with the mutilation and fragmentation of reproductive cells. Zygospores of *Sporodinia grandis* and *Spinellus fusiger* were chosen for experiment on the one hand, and asexual spores of *Pilobolus Œdipus*, *Phycomyces nitens* and *Mortierella reticulata* on the other. It was found to be a necessary condition that the body to be mutilated should be proximately homogeneous; so that in the case of zygospores the experimentation must occur either before perfect maturity, or after commencement of germination when the oil has disappeared. A second condition is that the fragment must not be too small. The process adopted was as follows:—Buddings from a zygospore germinating in a humid atmosphere were cut off as they appeared; after a time the contents of the Zygospore divided into a number of spores, separated by interstitial matter; the same result was obtained by similar treatment of an asexual spore; and if schizomycetous organisms were admitted into the culture-fluid, these endospores were produced without any buds.

M. Van Tieghem considers the cause which favours the formation of zygospores to consist in the air being impoverished of oxygen. He describes the germination of spores and zygospores in different media, and the structure and mode of dehiscence of the sporange in *Pilobolus* and *Pilaira*.

In the systematic portion of his memoir he describes new species of *Pilobolus*, *Rhizopus*, *Helicostylum*, *Thamnidium*, *Mortierella*, and *Syncephalis*, and characterizes a new genus, *Absidia*, with four species. This genus may be said to have the asexual growth of *Rhizopus*, and the sexual growth of *Phycomyces*. From the former it differs chiefly in having the sporangiferous stolons of a parabolic form and cuticularized throughout, the sporangia alternate with the rootlets, the columella conical and slender, the membrane of the spores not cuticularized and coloured, and the zygospores furnished with a *Phycomyces*-like investment. If a spore is kept in a nutritive medium it produces a mycelium; in a moist atmosphere, after having attained a certain size, it gives origin directly to a sporange without forming any mycelium. The zygospore behaves in a similar manner. Asexual spores, similar to the zygospores, are sometimes produced by a parthenogenetic process; these are termed *azygospores*.

The following is M. Van Tieghem's division of the Mucorineæ into tribes:—

No stylospores. A columella in the sporange, the membrane of which is. . . .	Heterogeneous, *i.e.*, formed of an upper cuticularized hood and a lower diffluent zone	*Piloboleæ*.
	Homogeneous, either all entirely persistent, or all diffluent . . .	*Mucoreæ*.
Stylospores present. No columella in the sporange, which is .	Spherical and isolated	*Mortierelleæ*.
	Cylindrical and grouped in capitula	*Syncephalideæ*.

—(*Journ. of Botany*, May 1878.)

Non-sexual Outgrowths on the Prothalli of Ferns.—The discovery of the non-sexual production of ferns from the prothallus originally made by Dr. Farlow has been confirmed by observations made upon several species. At the meeting of the Society of German Naturalists, held last year at Munich, Professor De Bary reported upon the subject as follows:—"Investigation has shown that some ferns, namely, *Pteris cretica*, *Aspidium falcatum*, and *Aspidium filix-mas*, var. *cristatum*, form normal antheridia on the prothalli, but generally no archegonia, or only imperfect ones which perish before the opening of the canal, and exhibit, instead of the typical formation of the embryo, the outgrowth described by Farlow. In those species which develope archegonia, no such outgrowth has been observed. The morphological phenomena presented by the shoot are alike in the species named, even in the smallest particulars. In the prothallus, which grows directly out of the spore, the development which occurs in most cases, and may be called normal, is as follows:—At the sinus, nearly at the spot where the first archegonium occurs, there arises a protuberance which grows out directly into a leaf; at the base of this, close by the insertion into the prothallus, there is formed an aerial *punctum vegetationis*, on which a second and the successive later leaves appear. At the base of the first leaf there is formed, endogenously on the vascular bundle, the first root. As soon as the second leaf appears the bud grows like an ordinary fern-shoot. Varia-

tions from the normal mode of growth are not uncommon. Frequently the prothalli form branches like themselves (secondary prothalli) which can again produce leaves and shoots in a great variety of forms. A moment's reflection shows that the three ferns in question have lost the power of forming archegonia, and with it, sexual reproduction; and as compensation for the loss of the sexual formation of the embryo, possess the power of forming the outgrowth described. This presents a special case of that general phenomenon which is called *apogamy*, total loss of reproductive power, and which consists in the fact that a species loses sexual reproduction, and acquires in its place numerous non-sexual modes of propagation, such as brood-buds, suckers, &c. The numerous bulblets of the higher Phanerogams, species of *Allium*, *Deutaria*, and the like, are examples of this, as well as of the successive degrees of difference in apogamy."—(*Silliman's Journal*, May 1878.)

CHEMISTRY.

Two allotropic Modifications of Magnetic Oxide of Iron.—When iron sesquioxide is heated for some hours to 350°—440° C. in an atmosphere of hydrogen or carbonic oxide, it is converted into the magnetic oxide. This substance is identical in properties with the product obtained either by calcining the hydrate of the magnetic oxide at 300° in a gas which is without action upon it, or by the decomposition of the carbonate of iron, or by the ignition of pyrophoric iron protoxide at a low red heat. It differs in a marked degree from that form of the magnetic oxide which we obtain on the employment of higher temperatures, whether by the decomposition of water by red hot iron, by burning iron in oxygen, or by the splitting up of the sesquioxide at a bright red heat. Magnetic oxide of iron, Fe_3O_4, is black and is strongly attracted by the magnet; that variety, however, which is formed at lower temperatures by the processes referred to has a specific gravity of 4·86, is acted upon by concentrated nitric acid, and can undergo further oxidation, being changed by rusting into sesquioxide. The magnetic oxide formed at the higher temperatures is not changed into sesquioxide when heated in the air, is not attacked by strong nitric acid, and has a specific gravity of 5·0—5·09. This is the variety which forms the little granules and spherules found in meteoric dust. Moissan, who has made these observations ("Compt. rend." 1878, lxxxvi. 600) determined some time since the existence of two allotropic modifications of iron protoxide: a pyrophoric modification obtained at temperatures between 350° and 450°, and a second and non-pyrophoric variety produced, as Debray has shown, at temperatures between 1000° and 1200°. The first variety when oxidized is converted into sesquioxide, the second forms magnetic oxide only, and of the kind which is produced at high temperatures. If pyrophoric iron protoxide, which would be converted into sesquioxide by exposure to the air, be heated to a low red heat in a current of carbonic acid, it is oxidized to magnetic oxide, carbonic oxide being formed; the variety of the magnetic oxide obtained by this operation [illegible]l in character with that obtained at low temperatures. If magnetic

oxide, prepared at 350°, be raised to bright red heat in a current of nitrogen it shrinks together, its specific gravity is changed, it can no longer be converted into sesquioxide; in short it possesses all the qualities of the magnetic oxide produced at 1200°. The result is the same when carbonic acid is employed in place of nitrogen, for the experiments of Gruner in 1872 established the fact that in a strongly heated atmosphere of carbonic acid, magnetic oxide alone is produced.

Revision of the Atomic Weight of Antimony.—Prof. J. P. Cooke has determined anew the atomic weight of this metal, and has devoted to that object much time and great care. He first found the weight of antimony sulphide, Sb_2S_3, obtained from a known quantity of antimony, taking the atomic weight of sulphur as 32. The red variety was dried at 180° C., and the grey modification in most instances at 210°. A mean of thirteen experiments, where the sulphide was dried at 180°, furnished the number 119·994, and a mean of eleven others where the compound was heated to 210° gave 120·295 as the number representing the atomic weight. In each case the author convinced himself that no free sulphur was present, and he took precautions to eliminate every possible source of error. In a second series of no less than seventeen estimations, where antimony chloride was employed, the atomic weight of the metal was found to be 121·94, a number which closely corresponds with that obtained by Dumas and Dexter. In this case, it should be stated, the atomic weight of chlorine was taken as 35·5, and that of silver to be 108. As each of the two series of experiments made by Cooke furnished numbers which closely correspond *inter se*, while the final results differ considerably, the author set himself to determine the atomic weight of sulphur. By reducing silver sulphide at a low red heat with dry hydrogen he found sulphur to be 31·158 if silver is 108, and 32·137 if silver is 107·93. In a fourth series of estimations Cooke determined the amount of bromine in antimony bromide, $SbBr_3$, and arrived at the number 120 as a mean of fifteen analyses. When he employed antimony iodide he again obtained the number 120, if the atomic weight of iodine be taken to be equal to 127 and that of silver 108; or 119·95 when the atomic weights of those elements are respectively held to be 126·85 and 107·93. The correct number appears to be 120, and the disparity appears to have arisen from the fact that it is impossible to prepare antimony chloride absolutely free from oxychloride ("Amer. Journ. Sc." 1878, xi. 41.)

A new Product of the Oxidation of Lead.—Red lead, as is well known, is prepared by heating litharge (lead oxide) in a fine state of division to 500° in presence of air. The oxide slowly takes up 2·3 per cent. of its weight of oxygen, and is converted into an oxide represented by the formula Pb_3O_4. Dumas regarded this body as a compound of lead oxide and lead peroxide—

$$2PbC + PbO_2 = Pb_3O_4.$$

Berzelius, on the other hand, believed it to consist of lead oxide and lead sesquioxide, and to resemble magnetic oxide of iron (Fe_3O_4) in point of constitution. Although he did not succeed in isolating the sesquioxide, it has now been shown by Debray ("Compt. rend." 1878, lxxxvi. 513) that such an oxide can under certain circumstances be formed. When lead peroxide is heated to 440° a brisk evolution of oxygen is observed to take place.

After the lapse of four or five hours the substance is entirely converted into red lead. If the lead peroxide be heated to 350° gas is plentifully evolved, but the action very soon ceases, and a product is obtained having exactly the composition of lead sesquioxide. It is a greenish-brown powder, which both in properties and in point of composition stands intermediate between red lead and lead peroxide. It can also be produced by heating lead oxide or, what is better, lead carbonate to 350° in a current of air or oxygen. The cause of the failure of the earlier chemists to isolate this oxide is clearly to be traced to their having employed too high temperatures.

The Restoration of Faded Handwriting.—In a paper on several interesting points connected with chemical technology ("Journ. prakt. Chem.," 1878, xvii. 83) von Bibra discusses the best means of rendering legible writing which in process of time has become obscure. He refers to the custom of employing freshly prepared ammonium hydrosulphate, which, he states, is to be applied with a brush, the excess to be removed with water and the paper or parchment then quickly dried between folds of blotting-paper. In the case where an important document is to be deciphered we cannot help regarding this as little else than heroic treatment, and prefer to pour the reagent in a watch-glass and to hold the manuscript over it, exposing it to the fumes of the strong hydrosulphate just so long as is necessary to develop the handwriting. At best the method is not a good one, because it converts the iron of the ink into the metallic sulphide which rapidly undergoes oxidation; the writing in a very short time will fade away as the sulphate is diffused through the moist paper, and the characters will appear blurred when any subsequent attempt is made to revive them. Von Bibra has now found in a moderately concentrated aqueous solution of tannin (gallotannic acid) an agent which produces the desired result, and at the same time possesses none of the disadvantages of the hydrosulphate. He applies the tannin solution with a brush, removes the excess by a current of water, and dries the document at a temperature of 50°—60° R. The writing developed in this manner is clear and very black, remaining so after the lapse of several months. These methods, it need hardly be stated, refer only to manuscripts where ordinary ink has been employed, and not to documents written with Indian or carbon ink.

The Chemical Action of the Electric Discharge on Persulphuric Acid.—As this acid can be formed by the action of oxygen on sulphurous acid (*see Popular Science Review*, April, 1878, 207) it occurred to Berthelot that it may also be prepared by the direct action of oxygen on sulphuric acid $S_2O_6 + O = S_2O_7$. This fact he has now established ("Compt. rend." 1878, lxxxvi. 277). He subjected 277 milligrammes of sulphuric anhydride in contact with 60 ccm. of dry oxygen to the action of the electric discharge for the space of eight hours; the tube containing these materials was then heated to remove a few little drops of unaltered anhydride, and he then continued the transmission of the current for some hours. By this time the anhydride had completely disappeared, and in the place of it there was a substance closely resembling persulphuric acid. Rather more than 20 ccm. of the gas had disappeared. The new body possessed the composition of [illegible]uric acid. It was found that the anhydride and oxygen, when [illegible]ther, do not enter into combination unless the electric currents

are employed. Persulphuric acid prepared in this manner is not a permanently stable body. The beautiful crystalline needles begin to crumble away in a few days, and are soon converted into a snow-like mass, which appears to be a compound of sulphuric acid and persulphuric acid. The same substance is formed when the discharge is first transmitted, and appears consequently to be an intermediate product.

Fluoranthene.—This is a new hydrocarbon obtained by Fittig and Gebhard from coal tar ("Ber. deutsch. chem. Gesell. Berlin." x. 2141). In preparing and purifying a large quantity of pyrene, a substance was discovered having the formula $C_{15}H_{10}$, fusing at 100° and crystallizing in large lustrous plates. This is the new body. When treated with the requisite reagents it yielded the picric acid compound $C_{15}H_{10} + C_6H_3(NO_2)_2O$ and the trinitro-derivative $C_{15}H_7(NO_2)_3$. When oxidized with chromic acid solution it, like phenanthrene, evolves carbonic acid and is converted into a mixture of a chinone and an acid having the formula $C_{14}H_8O_3$; the barium salt of this body crystallizes in little warty concretions and the calcium salt in small golden-yellow needles. It is isomeric with oxyanthrachinone, but has the same empirical formula only as that body. It is undoubtedly an acid, containing beyond all question the group COOH. When distilled with finely divided zinc it yields nearly the theoretical amount of fluorene, and when heated with lime splits up into carbonic acid and diphenylenketone, which has led the authors to give it the name of diphenylenketon carbonic acid. Fittig believes the idryl of Goldschmiedt to be identical with fluoranthene.

The Reaction of Nitrogen and Water.—Berthelot, having had occasion to repeat the experiments on the formation of ammonium nitrite by means of the electric discharge, now finds that absolutely pure nitrogen when exposed in the concentric tubes, in contact with water, to the discharge of a powerful Ruhmkorff apparatus for from eight to ten hours yields ammonium nitrite beyond all question. The salt does not appear to be formed unless the discharge is a powerful one. With currents of low tension nitric acid is not formed in moist air. The formation of nitrates and nitrites in atmospheric air is assumed therefore to be due to the action of lightning ("Ann. Chem. Phys." [5], xii. 445). It must not, however, be forgotten that Zöller and Grete have reopened the inquiry whether ammonium nitrite is a product of the combustion of hydrogen in air, and the result of the experiments, conducted under most rigorous conditions, goes to show that during the combustion of absolutely pure hydrogen in perfectly pure air, small but distinct quantities of the nitrite are formed. ("Ber. deut. chem. Gesell. Berlin." x. 2144.)

GEOLOGY AND PALÆONTOLOGY.

The Date of the Last Glacial Epoch.—Mr. N. H. Winchell has communicated a paper to the Geological Society in which he endeavours to determine the date of the final cessation of glacial conditions in North America by determining the rate of recession of the Falls of St. Anthony, which are situated near the junction of the Minnesota and the Mississippi. These

falls have been known to Europeans about 200 years. The country is covered with deposits of glacial origin, and between Fort Snelling and the present Falls, a distance of eight miles, the existing river-gorge has been formed since the deposition of the newer Boulder-clay. The old river-valley is filled up with glacial deposits. The gorge is of very uniform character, being cut through hard limestones resting on soft sand rock, both lying quite horizontally. The country was settled in 1856, and the recession of the falls has since been very rapid, its rate having been accelerated by the erection of saw-mills, dams, &c. From the accounts of various travellers who have visited the falls in the last 200 years, Mr. Winchell endeavours to obtain an estimate of the true rate of recession. Between the visit of Father Hennepin in 1688 and that of Carver in 1766 he finds a recession at the rate of 3·49 feet annually; between Carver's visit and 1856, a mean annual recession of 6·73 feet; and between Hennepin and 1856, one of 5·15 feet. The time-estimates for the cutting of the gorge would be, according to the above means, 12, 103, 6, 276 and 8, 202 years. Mr. Winchell considers the data upon which the second of these numbers is founded the most reliable. Sir Charles Lyell's estimate of the recession of the Falls of Niagara from the escarpment at Queenstown to their present site is 35,000 years.

The Mosasaurs.—Professor O. C. Marsh has obtained the materials for a complete reconstruction of the fore-limb of *Lestosaurus*, an American type of Mosasaurs. Professor Owen has instituted a comparison of the characters of this limb, as shown in Professor Marsh's figure, with the bones of the same parts in cetaceans, plesiosaurs, and lizards. He finds the characters presented to approach most closely to those of the last-named order of Reptiles, of which *Monitor niloticus* was taken for comparison. Hence he regarded his view, originally stated in 1851, that the Mosasaurs form a tribe, *Natantia*, in the Reptilian order Lacertilia, as confirmed; and he compared the relations of these reptiles to the other lizards with those of the seals to the ordinary carnivorous mammals.—(*Proc. Geol. Soc.*, 5 June 1878).

Palæozoic Rocks under London.—Professor Prestwich has given a most interesting account of the results of the deep well-boring recently made at Messrs. Meux's brewery, at the south end of Tottenham Court Road. He remarks that the well-known boring at Kentish Town, in 1856, showed the absence at that point of Lower Greensand, the Gault being immediately succeeded by hard red and variegated sandstones and clays, the age of which was at first doubtful, but which were finally considered to approach most nearly to the Old Red Sandstone near Frome, and to the Devonian sandstones and marls near Mons, in Belgium. The existence of some doubt as to this identification rendered the boring lately made at Messrs. Meux's brewery particularly interesting, and the method of working adopted by the Diamond-boring Company, by bringing up sharply cut cores from known depths, gave special certainty to the results obtained. The boring passed through 352½ feet of Chalk, 28 feet of Upper Greensand, and 160 feet of Gault, at the base of which was a seam, three or four feet thick, of phosphatic nodules and quartzite pebbles. Beneath this was a sandy calcareous stratum of a light [illegible]lour, passing into a pale or white limestone, and this into a rock of [illegible]t. Casts and impressions of shells found in this bed showed

it to be the Lower Greensand, whose place it occupied. The boring was carried further in the hope of reaching the loose water-bearing sands of this formation, but the rock became very argillaceous, and, when 62 feet of it had been passed through, the boring entered into mottled red, purple, and greenish shales, dipping at 35° in an unascertained direction. These beds continued through a depth of 80 feet, when, their nature being clearly ascertained, the boring was stopped. The fossils of these coloured beds, which included *Spirifera disjuncta*, *Rhynchonella cuboides*, and species of *Edmondia*, *Chonetes*, and *Orthis*, show them to be of Devonian age. Thus, the existence of Palæozoic rocks at an accessible depth under London, and the absence of the Jurassic series, as maintained long since by Mr. Godwin-Austen, is experimentally demonstrated.

These facts are of interest in connection with the question of the possible extension of the Coal-measures under the Cretaceous and Tertiary strata of the south-east of England. The beds found at the bottom of Messrs. Meux's boring are of the same character as the Devonian strata which everywhere accompany the Coal-measures in Belgium and the north of France, being brought into juxta-position with them by great faults and flexures. A remarkable section at Auchy-au-Bois, in the western extremity of the Valenciennes coal-field, is particularly interesting from its furnishing evidence that the Hardinghen coal-field, between Calais and Boulogne, is a prolongation of that of Valenciennes, and because the same strike and a prolongation of the same great fault observed at Auchy-au-Bois through Hardinghen would carry the southern boundary of any coal-field in the south-east of England just south of Maidstone, thence passing a little north of London. Hence it is in the district north of London that there is most probability of the discovery of the Carboniferous strata. The extent of country in which shafts could be sunk to the Palæozoic strata will, however, be limited by the presence of the water-bearing Lower Greensand, which probably reaches close to London in the south, reappears in Buckinghamshire and Bedfordshire, 30 or 40 miles north of London, and probably extends some distance towards the city under the Chalk hills of those counties and Hertfordshire.

The nature of the representative of the Lower Greensand in the boring, and the characters of the fossils contained in it, lead to the conclusion that in it we have a deposit produced near the shore of the Neocomian sea, here probably consisting of cliffs of Devonian (or Carboniferous) rock. From these cliffs the calcareous material which here replaces the usual loose sands of the Lower Greensand was perhaps derived by the agency of springs; and the shore-line itself must be situated between the south end of Tottenham Court Road and the Kentish Town boring. The sandy beds of the Lower Greensand will probably be found to set in at no great distance to the southward, presenting the conditions necessary for storing and transmitting underground waters. A test boring made by Mr. H. Bingham Mildmay at Shoreham Place, about five miles from Sevenoaks, and in which the Lower Greensand was met with at about the estimated depth (450 feet) and furnished a supply of water, seems to confirm these views.

A Fossil Passerine Bird from Colorado.—The wonderful insect-bearing deposits of Florissant, Colorado, have furnished the remains of a Passerine bird, the first of its type that has yet occurred on the American continent.

These remains consist of the greater part of the skeleton, but the thighbones, the beak, and the anterior part of the head are wanting. The slab containing the specimen also shows remarkably distinct impressions of the feathers of the wings and tail. In size and general proportions the bird resembles the Scarlet Tanager (*Pyranga rubra*), and the Cedar Bird (*Ampelis cedrorum*); in the development of the wings it also agrees with those birds, but the legs and feet are smaller and weaker. The total length of the bird was about seven inches. Dr. Allen regards its organization as indicating arboreal habits and considerable power of flight. The absence of the bill renders it impossible to decide as to the particular family to which this bird should be allied, but the balance of the evidence from these remains is in favour of its being a finch. Dr. Allen proposes to found a new genus for the bird, which he names *Palæospiza bella*. Other remains of birds have been found in the Florissant beds.—(*Silliman's Journal*, May 1878.)

American Permian Reptiles.—Professor Marsh notices some reptiles from a peculiar lacustrine formation in the Western Territories, but especially from New Mexico, the geological position of which appears to him the upper part of the Permian. Among them are several genera showing the more important characters of the Rhynchocephala, of which the New Zealand *Hatteria* is the sole living type. One remarkable characteristic of all the reptiles here noticed is the presence of intercentral ossifications below the biconcave bodies of the vertebræ; and another the existence of three facets for the articulation of the ribs in the anterior rib-bearing vertebræ. In the implantation of the teeth and their successional development, these reptiles resembled the Mosasaurs. They represent two families, which Professor Marsh calls Nothodontidæ and Sphenacodontidæ. The former includes a single species, *Nothodon lentus*, which was probably five or six feet long, slow in its movements, partially aquatic and herbivorous. Three species of the second family are described, namely:—*Sphenacodon ferox*, a carnivorous reptile about six feet long, with the posterior teeth compressed, with very sharp smooth edges; *Ophiacodon mirus*, also a carnivorous form, about the same size as the preceding, with conical teeth, of which the anterior are recurved as in serpents; and *O. grandis*, a larger species, about ten feet in length.—(*Silliman's Journal*, May 1878.)

The First American Jurassic Mammal.—Professor Marsh says, "One of the most interesting discoveries made in the Rocky Mountain region is the right lower jaw of a small mammal recently received at the Yale College Museum. The specimen was found in the *Atlantosaurus*-beds of the Upper Jurassic, and the associated fossils are mainly Dinosaurs.

Dryolestes priscus, gen. et sp. nov.

"This specimen is in fair preservation, although most of the teeth have been broken off in removing it from the rock. The penultimate molar, however, remains. The shape of the jaw, and the position and character of the teeth, show that the animal was a small marsupial, allied to the existing Opossums (*Didelphidæ*). The tooth preserved has the same general form as the corresponding molar of *Chironectes variegatus* Illiger. The angle of the jaw is imperfect, but there are indications that it was inflected.

"The principal dimensions of this specimen are as follows:—

Space occupied by seven posterior teeth . . .	12·5mm.
Depth of jaw below last molar	4·4
Transverse diameter	1·8
Height of crown of penultimate molar . . .	2·
Transverse diameter	1·5

"The present specimen indicates an animal about as large as a weasel. It is of special interest, as hitherto no Jurassic mammals have been found in this country."—(*Silliman's Journal*, June 1878.)

Arctic Geology.—The last British Polar Expedition under Sir George Nares hardly satisfied the expectations of the public, but we are gradually learning that its scientific results are by no means to be despised. Captain Feilden, the naturalist to the expedition, devoted a good deal of his attention to the geology of the region explored, and the fruits of his researches add considerably to our knowledge of Arctic Geology. A long paper on this subject was read before the Geological Society on April 17, by Captain Feilden and Mr. De Rance, in which they described the Laurentian gneiss that occupies so large a tract in Canada as extending into the Polar area, and alike underlying the older Palæozoic rocks of the Parry Archipelago, the Cretaceous and Tertiary plant-bearing beds of Disco Island, and the Oolites and Lias of East Greenland and Spitzbergen. Newer than the Laurentian, but older than the fossiliferous rocks of Upper Silurian age, are the Cape-Rawson beds, forming the coast line between Scoresby Bay and Cape Cresswell, in lat. 82° 40′; these strata are unfossiliferous slates and grits dripping at very high angles.

From the fact that Sir John Richardson found these ancient rocks in the Hudson's Bay territory to be directly overlain by limestones containing corals of the Upper Silurian Niagara and Onondaga groups, Sir Roderick Murchison inferred that the Polar area was dry land during the whole of the interval of time occupied by the deposition of strata elsewhere between the Laurentian and the Upper Silurian; and the examination by Mr. Salter, Dr. Haughton, and others of the specimens brought from the Parry Islands have hitherto been considered to support this view. The specimens of rocks and fossils, more than 2,000 in number, brought by the late expedition from Grinnell and Hall Lands have made known to us, with absolute certainty, the occurrence of Lower Silurian species in rocks underlying the Upper Silurian; and as several of these Lower Silurian forms have been noted from the Arctic Archipelago, there can be little doubt that the Lower Silurians are there present also. The extensive areas of dolomite of a creamy colour abounding in fossils discovered by M'Clintock around the magnetic pole, on the western side of Boothia, in King William's Island, and in Prince of Wales Land, described by Dr. Haughton, probably represent the whole of the Silurian era and possibly a portion of the Devonian.

The bases of the Silurians are seen in North Somerset, and consist of finely stratified red sandstone and slate, resting directly on the Laurentian gneiss, resembling that found at Cape Bunny and in the cliffs between Whale and Wolstenholme Sounds. Above these sandstones occur ferruginous limestones, with quartz grains, and still higher in the series the

cream-coloured limestones come in. The Silurians occupy Prince Albert Land, the central and western portion of North Devon, and the whole of Cornwallis Island. The Carboniferous Limestone was discovered, rising to a height of 2,000 feet, on the extreme north coast of Grinnell Land, in Feilden and Parry Peninsulas, and contains many species of fossils in common with the rocks of the same age in Spitzbergen and the Parry Archipelago, being probably continuously connected with the limestone of that area, by way of the United States range of mountains. The coal-bearing beds that underlie the Carboniferous Limestones of Melville Island are absent in Grinnell Land, but they are represented by true marine Devonians, established in the Polar area for the first time, through the determination of the fossils, by Mr. Etheridge. In America a vast area is covered by Cretaceous rocks. The lowest division, the Dakota group, contains lignite-seams and numerous plant-remains indicating a temperate flora; overlying the Cretaceous series are various Tertiary beds, each characterized by a special flora, the oldest containing subtropical and tropical forms, such as various palms of Eocene type. In the overlying Miocene beds the character of the plants indicates a more temperate climate, and many of the species occur in the Miocene beds of Disco Island, in West Greenland, and a few of them in beds associated with the 30-feet coal-seam discovered at Lady Franklin Sound by the late expedition. The warmer Eocene flora is entirely absent in the Arctic area, but the Dakota beds are represented by the 'Atane strata' of West Greenland, in which the leaves of dicotyledonous plants first appear. Beneath it, in Greenland, is an older series of Cretaceous plant-bearing beds, indicating a somewhat warmer climate, resembling that experienced in Egypt and the Canary Islands at the present time. In the later Miocene beds of Greenland, Spitzbergen, and the newly-discovered beds of Lady Franklin Sound, the plants belong to climatal conditions 30° warmer than at present, the most northern localities marking the coldest conditions. The common fir (*Pinus abies*) was discovered in the Grinnell Land Miocene, as well as the birch, poplar, and other trees, which doubtless extended across the Polar area to Spitzbergen, where they also occur.

At the present time the coasts of Grinnell Land and Greenland are steadily rising from the sea, beds of glacio-marine origin, with shells of the same species as are now living in Kennedy Channel, extending up the hill-sides and valley slopes to a height of 1,000 feet, and reaching a thickness of from 200 to 300 feet. These deposits, which have much in common with the 'boulder-clays' of English geologists, are formed by the deposition of mud and sand carried down by summer torrents and discharged into fiords and arms of the sea, covered with stone- and gravel-laden floes, which, melted by the heated and turbid waters, precipitate their freight on the mud below. As the land steadily rises these mud-beds are elevated above the sea. The coast is fringed with the ice-foot, forming a flat terrace 50 to 100 yards in breadth, stretching from the base of the cliffs to the sea-margin. This wall of ice is not made up of frozen sea-water, but of the accumulated autumn snowfall, which, drifting to the beach, is converted into ice where it meets the sea-water which splashes over it. As a supplement to this memoir a very extensive and important paper on the fossils brought by C[illegible]len, was read by Mr. Etheridge, in which he remarked espe-

cially on the presence of undoubted Silurian and Carboniferous fossils at the highest latitude yet reached, namely 82° 45′ north.

Stromatopora and Loftusia.—Principal Dawson has contributed a statement of his views as to the nature of those problematical fossils from the Palæozoic rocks which are commonly known as *Stromatopora*. They are massive fossils, often showing concentric structures when weathered, and have been referred by different writers to the Sponges, to the Corals, to the Hydroida as allied to *Hydractinia*, and to the Foraminifera. Principal Dawson says that *Stromatopora* is "a calcareous, non-spicular body, composed of continuous concentric porous laminæ, thickened with supplemental deposit, and connected by vertical pillars, most of which are solid;" and he maintains his old opinion that *Stromatopora* is a Foraminiferal organism and the Palæozoic representative of the Laurentian *Eozoon*.

Dr. G. M. Dawson has made the interesting discovery of a species of *Loftusia* in a Limestone, probably of Carboniferous age, which occurs in British Columbia in the banks of Marble Cañon, Frazer River. He names this species *Loftusia columbiana*. As the genus *Loftusia* was established for the reception of a tertiary Persian fossil Foraminifer, this discovery is of great interest provided the reference of the North American form to this genus be confirmed. *Loftusia columbiana* is much smaller than *L. persica* (0·3 inch long); it occurs here and there in patches in the limestone, but the number of specimens when it does appear is very great.—(*Proc. Geol. Soc.*, June 5, 1878.)

MICROSCOPY.

The New Oil-immersion Object-glass.—The Rev. W. H. Dallinger writes to "Nature":—"As a piece of workmanship this lens is extremely fine; and it can be used with quite as much ease as an ordinary immersion quarter-inch objective. It works admirably with Powell and Lealand's ordinary sub-stage condenser, with Wenham's reflex illuminator, and with the small plano-convex lens which the maker sends with it to be fastened to the under surface of the slide with the oil of cedar wood. But I have also secured admirable results with the illuminating lens of Powell and Lealand's supplementary stage, which gives entire command over the angle of the illuminating ray.

"The spherical aberration is beautifully corrected, the field being perfectly flat. The colour corrections are, so far the lens goes, equally perfect; but are somewhat conditioned by the dispersive power of the oil, which can be modified readily. The sharpness and brilliance of the definition which this lens yields are absolutely unsurpassed, in my experience; and it has a very great power of penetration.

"I tested it with a series of tests with which I have proved and compared the glasses of various makers in England, the Continent, and America, for some years. Up to the time of receiving this lens, the $\frac{1}{8}$-inch that had done the most in my hands was one of the 'new formula' lenses of Powell and Lealand. It is but justice to say that all my most crucial tests were equally mastered by the lens of Zeiss. I have not been able to do more with it than with the English glass, *but the same results* can be accom-

plished *much more readily*. The correction has to be brought into operation, and careful adjustment made, to get the finest result with the English lens; but the German glass has simply to be brought into focus, and the best result is before the observer, provided that the light has been adjusted in the most efficient manner. It is true that for sharp and perfect definition we must be careful to adjust the length of the draw-tube; in working this lens there is much need of attention to this matter; and speaking from a practical point of view, it takes the place, in securing crisp definition, of the screw-collar adjustment, although, of course, much easier of application. But it is so easy to work the lens with fine results on the more delicate tests, that I think that those who make the resolution of these their primary object in the possession of a microscope, can scarcely fail in securing their utmost desire. It is a glass pre-eminently suited for the resolution of difficult lined or beaded objects.

"*Amphipleura pellucida* is easily resolved into delicate beads when the frustules are moderately coarse; and almost any that can be met with are resolvable into lines; and this, when these diatoms are mounted in balsam. The highest eye-pieces made may be used without any practical detriment to the image, although, of course, with a reduced sharpness of definition.

"On the whole, I think it in many cases the finest lens, of its power, that I have ever seen; and in every sense it is an admirable acquisition."

There is one drawback, viz., that the oil is a solvent of most varnishes and gums used in mounting and finishing slides (which may be remedied by coating the edge of the cover with shellac varnish); and also the necessity for the objects, such as frustules of diatoms, to be "burnt" on to the cover or mounted in balsam or other fluid with an equal refractive index.

MINERALOGY.

New Minerals from Laangban.—A number of new and interesting mineral species from this locality have been described by A. E. Nordenskjöld (*Jahrbuch für Mineralogie*, 1878, 206.) Atopite is the name given to a yellowish-brown or resin-brown, semi-translucent mineral which possesses the following composition:

Antimonic acid	72·61
Lime	17·85
Iron protoxide	2·79
Manganese protoxide	1·53
Potash	0·86
Soda	4·40
	100·04

The antimony appears to be present in the form of the higher oxide of that metal; and the analytical numbers correspond with the formula $2RO,Sb_2O_5$. Monimolite and romeite are the minerals most closely allied to the new species; it differs from the former in containing no lead oxide and a larger portion of antimonic acid, and from the latter in the ratio of base to acid and in that all the antimony is present in the form of antimonic

acid. Atopite is found at Laangban disseminated through hedyphane which occurs in fine veins and layers in rhodonite. It crystallizes in regular octahedra, and has a hardness of 5·5-6·0, and the specific gravity of 5·03.—Ekdemite is a coarsely crystalline mineral of a bright yellow colour with a faint greenish tinge; in thin plates it is translucent and is uniaxial and exhibits a distinct basal cleavage. The hardness is 2·5–3·0 and the specific gravity = 7·14. The solution of this mineral in acid reduces potassium permanganate. A pure specimen of ekdemite was found to possess the following composition:

Lead oxide	58·25
Lead	23·39
Chlorine	8·00
Arsenious acid	10·60
	100·24

These numbers indicate the formula $5PbO,As_2O_3 + 2PbCl_2$ as that of the new species. The mineral occurs, imperfectly foliated, in manganocalcite and as greenish yellow deposits incrusting it. The author also found at Laangban small lemon-yellow granules enclosed in the calcite which fills the cavities of a resin-brown coloured garnet; these granules contain arsenic, lead, and chlorine, but a satisfactory analysis of them could not be performed from want of material. He states that they crystallize in the rhombic system, and regarding them as ekdemite, he believes the new mineral to be dimorphous.—Hydrocerussite is a white mineral enclosing native lead; it appears to be a hydrated lead carbonate having the composition represented by the formula $2PbO,CO_2 + H_2O$. Hyalotekite is a white or pearl-grey, semi-translucent mineral, possessing a coarsely crystalline structure, and cleaving in two directions lying 90° or nearly 90° apart. It is easily fusible and is insoluble in hydrochloric acid and sulphuric acid. An imperfect analysis showed it to contain the following ingredients:

Silicic acid	39·62 per cent.
Lead oxide	25·30 „
Baryta	20·66 „
Lime	7·00 „
Loss on ignition	0·82 „
Alumina, potash, &c.	not determined.

In appearance it very closely resembles a greyish-white felspar, and it occurs in association with hedyphane and schefferite.—Ganomalite is the name which was given by the author in 1876 to a lead silicate occurring at Laangban. As it has recently transpired that certain specimens which were believed to be ganomalite contain no lead whatever, and are in reality tephroite (manganese silicate), Nordenskjöld has published fuller details and an analysis of the mineral. Ganomalite occurs massive, associated with tephroite, which it so closely resembles that any specimen under examination should be tested with the blowpipe. It is white or greyish-white, possesses marked doubly refractive power, has a hardness of 4·0, and the specific gravity of 4·98. When heated with soda in the reducing flame, the yellow crust on the charcoal and the reduced metal indicate the presence of lead. The composition of a specimen of this mineral was found to be:—

Silicic acid	34·55
Lead oxide	34·89
Manganese protoxide	20·01
Lime	4·89
Magnesia	3·68
Alkalies, &c.	1·86
	99·88

On one specimen, which appeared to be ganomalite in the crystallized condition, the angle between two planes of cleavage was found to be 104° 33′. The last of the minerals mentioned in this interesting paper has been termed jacobsite. It has strongly developed magnetic characters, and contains, in addition to some constituents which are apparently accidentally present, the following oxides:

Iron oxide	58·39 per cent.
Manganese oxide	6·96 ,,
Manganese protoxide	29·93 ,,
Magnesia	1·68 ,,

The formula of jacobsite appears therefore to be $MnO(Fe_2O_3, Mn_2O_3)$.

Adamite.—This mineral, a zinc arsenate, hitherto met with at Chanarcillo, Chili, and the Mine de la Garonne, has been found by Laspeyres in the calamine deposits of Laurium. It forms small crystals of a greenish hue, and occurs in the cavities of the rose-red or reddish massive ore of the Greek mines, associated with arseniosiderite, crystallized smithsonite, and sometimes with mimetesite. Its crystallographic characters were found not to differ materially from those of the specimens of adamite from Chanarcillo. Braun draws attention (*Jahrbuch für Mineralogie*, 1878, 188) to the interesting group of minerals, more than twenty in number, occurring in the Laurium beds, and points out the advantages which would accrue to science if they could be examined *in situ* by a good mineralogist. The ore which is now being raised is calcined before it is shipped and the minerals associated with the calamine are consequently destroyed.

The Separation of Minerals of Different Specific Gravities.—Church has recently called attention to the applicability of Sonstadt's solution to the separation of minerals of different specific gravity. The liquid consists of a solution of mercury iodide in potassium iodide, and is prepared by adding them alternately to the solution until no more of either is dissolved. A little free iodine occasionally colours the liquid, but this can be removed by the addition of some sodium hyposulphite. The light straw coloured liquid thus obtained may possess a specific gravity of 3·01 and can be employed for the separation of the mechanically loosened ingredients of any rock which it is desired to examine. Hardman describes the successful isolation by this means of a mineral occurring in a basalt of the North of Ireland. He used a solution having a specific gravity of 2·40, and was enabled to isolate two grammes of a mineral having a specific gravity of 1·70. This quantity the author questions his ability to have extracted after months of labour by any other method. He points out that it will now be possible to completely separate the three constituent minerals of granite—mica, felspar, and quartz, [illegible]hem and to determine almost absolutely their percentage, a [illegible]ch has as yet only been solved by mathematical calculation,

based on assumptions which can at best be merely approximately correct.—(*Chemical News*, 1878, xxvii. 108.)

In the current number of the *Mineralogical Magazine*, Prof. Heddle, of St. Andrews, draws attention to two properties of Sonstadt's "solution" which cannot too soon be impressed upon those who purpose to use it: it is a rapid and powerful vesicant, and it is exceedingly poisonous. It happened that some drops fell upon one of his hands, which was soon found to be in a state of violent inflammation. He does not regard the liquid as a "solution" in the strictest sense, but believes that a new salt is formed, which crystallizes in long needles apparently belonging to the oblique prismatic system; they have a highly dispersive power, a sulphur yellow colour, and are extremely deliquescent.—(*The Mineralogical Magazine*, 1878, ii. 63.)

Fluid Cavities in Blende.—A. Schortel has remarked the occurrence of a cavity, of nearly the size of a pea, and filled with liquid, in a specimen of Spanish blende. When the specimen was broken through the liquid was ejected. The walls of the cavity and the cleavage-faces were washed with distilled water and the transparent liquid qualitatively examined. The solution appears to have contained sodium chloride and zinc sulphate, the former predominating (*Berg. und Hüttenm.-Zeitung*, xxxvii. 49). Little cubes of salt have not unfrequently been observed in fluid cavities of other minerals.

A Société de Minéralogie has been formed in Paris. M. des Cloiseaux is president, and the meetings are held on the second Tuesday of each month in the Mineralogical Laboratory of the Sorbonne.

PHYSICS.

The Microphone.—It was announced early in May last that Professor Hughes, the inventor of the type-printing apparatus, had made the discovery that certain bodies placed in the circuit of a small battery were so affected by the sonorous vibrations of speech as to replace the transmitter of a Bell Telephone.

The instrument producing such remarkable results was described at the meeting of the Royal Society on the 9th of that month.

The telephone was employed as a phonoscope or receiving instrument of great delicacy, a small Daniel's battery being introduced into its circuit. It was first noticed that if a stretched wire were made part of this circuit, and the strain increased until it broke, a sound was heard at the moment of breaking, and repeated if the broken ends were pressed together.

"It was soon found that it was not at all necessary to join two wires endwise together to reproduce sound, but that any portion of an electric conductor would do so, even when fastened to a board or to a table; no matter how complicated the structure upon this board, or the materials used as a conductor, provided one or more portions of the electrical conductor were separated, and only brought into contact by a slight but constant pressure. Thus, if the ends of the wire terminating in two common nails laid side by side, and separated from each other by a small space, be electrically connected by laying a similar nail between them, sound could be repro

duced. The effect was improved by building the nails log-hut fashion into a square figure, using ten or twenty nails. A piece of steel watch-chain acted well. Up to this point, the coarser vibrations alone were produced, the finer inflections were missing; in other words, the *timbre* of the voice was wanting, but in the following experiment it became more and more perfect, until it reached a perfection leaving nothing to be desired."

Mr. Hughes tried all forms of pressure and modes of contact. All metals could be made to produce identical results, provided the division was small enough, and that the material used did not oxidize by contact with the air filtering through the mass. A mass of shot is peculiarly sensitive to sound while clear, but as the shot soon becomes coated with oxide, this sensitiveness ceases. Carbon, from its surface being entirely free from oxidation, is excellent, but the best results at first attained were from mercury in a finely divided state. He used the willow-charcoal employed by artists for sketching, heating it gradually to a white heat, and then plunging it suddenly into mercury. The pores thus being filled with innumerable minute globules, held it in a state of fine division. Tin and zinc answered the same purpose. Pine charcoal thus treated with iron developed high conductive powers though of itself a non-conductor.

The substances were at first confined in a glass tube or box provided with wires for introducing them into the circuit.

The conductors were found to be affected by sounds absolutely inaudible except by this means, and hence the instrument was termed the Microphone.

In its later form it consists of a lozenge-shaped piece of gas-carbon 1 inch long, $\frac{1}{4}$ inch wide at the middle, and $\frac{1}{8}$ inch thick, the lower pointed end pivots upon a similar block; all these pieces of carbon being tempered in mercury.

The tube-transmitter exhibited to the Royal Society consisted of a glass tube 2 inches long and $\frac{1}{4}$ inch in diameter, containing four separate pieces of willow-charcoal pressed together till the resistance was about a third of that of the line in which it was to be employed.

Since then many and various forms have been adopted with success. A sphere of carbon, resting loosely between two hemispherical depressions in blocks of the same material answers well; and a pretty as well as a sensitive modification is made by Mr. Yeates of King Street, Covent Garden, consisting of a short cylinder of battery-carbon 1 inch long and $\frac{1}{4}$ inch diameter, pivoted loosely at its central point and resting by one end on a small carbon anvil, the pressure on which can be regulated, either by a superimposed weight or by a small spiral spring. All modifications are mounted on thin resonance-boards of pine, by which the aerial vibrations are caught and intensified as by the sound board of a violin.

By the kindness of Professor Hughes, the writer has been enabled to examine the last shape adopted. It consists of a small resonance box of light wood, like that of a tuning-fork, within which is a vibrating plate of iron about $1\frac{1}{4}$ inch long, and $\frac{1}{2}$ inch broad, pivoted, as in the previous case, about its centre, and held down on the contact-anvil by a light spring, capable of opposing a weight of from 5 to 20 grains. The contact pieces are [illegible]tery-carbon. If two of these microphones and two ordinary [illegible] included in the same battery circuit, a curious fact comes to

light; for the two microphones being held to the lips of the communicating parties, and the telephones to their respective ears, each observer hears a note sung by the other, but not that which he is himself simultaneously emitting. The explanation of this undoubted phenomenon is somewhat obscure.

Dr. C. William Siemens, at a discussion before the Society of Telegraph Engineers, referred to the intimate connection between the microphone and its two elder sisters, the telephone and phonograph, in conjunction with which it formed a discovery which would probably be hereafter regarded as one of the greatest achievements in natural science of the present century.

He further compared the phonograph with the action of the brain in the exercise of memory, the external impressions being communicated to corpuscular bodies imbedded in grey substance, and connected with the nervous system of volition. Fresh impressions may be understood to give rise then and there to acts of will, but how stands the case with impressions communicated years before, and, as we term it, "Committed to Memory"? In order to this, the mind must have some power of reproducing a material record by which the impression has been rendered permanent. Such a hypothesis might also explain the confused images of dreaming, and the more vivid recollection of what occurred in early life, when the mechanical record may be supposed to have been distinct and indelible. It was also possible, by studying the action of selenium substituted for carbon in the microphone, that the impressions received by the retina would be equally susceptible of storage. The record itself might be supposed to be mechanical, more probably, molecular, at any rate, material.

Mr. Seabrooke points out that the microphone does not, strictly speaking, magnify the original sound, but substitutes for it a varying electric current of extreme rapidity. "In gently brushing the stand of the instrument, sound is heard in the telephone, but it does not at all follow that what we hear is a magnified reproduction of the brushing sound, for if the rapidity of the vibrations is insufficient to produce a sound, still they may move the carbon sufficiently to produce alternations of current, each of which may be able to set up vibrations of the telephone plate in its own period, or a modification of it."

Mr. F. J. M. Page introduces a Du Bois Reymond's induction coil by its primary into the microphonic circuit, the secondary coil being connected with a Lippmann's capillary electrometer, which immediately gives large and definite movements of its column.

Sir Henry Thompson demonstrated the surgical value of the microphone on June 4, in the Anatomical Theatre of University College. The sound used for detecting stone in the bladder was connected with the circuit, and whenever it struck the smallest fragment of calculus, the result was clear and unmistakable. Bullets and fragments of bone, he stated, might, by a similar process, be discovered.

On the day previous to Sir H. Thompson's demonstration, Mr. James Blyth brought before the Royal Society of Edinburgh a still simpler form of the microphone. He includes in the circuit "a small jelly can," half filled with cinders broken into coarse fragments, the connection being made by slipping down at opposite sides, between cinders and jar, two slips of tin

to which the wires are attached. Articulate sounds were thus heard very loud and distinct, though occasionally marred by the rattling of the cinders in the jar.

He then filled a shallow box of thin wood with cinders, nailing to its two ends tin connections. It proved to be a very sensitive transmitter, and if three such boxes were hung like pictures on the walls of a room almost any noise made in the room was revealed. A part song by two voices was distinctly transmitted. When water was poured into the original can, the Leclanché cell could be dispensed with.

It proved that the jar of cinders would act as a receiver as well as a transmitter. Two Grove's cells were included in circuit, and articulate sounds were clearly heard. The magnetic element of the telephone was here entirely superseded.

To demonstrate the actual motion and vibration of the cinders under the influence of sound, a strong battery and a glass jar were used. In a dark room flashes of electric light were observed between the fragments.

In a paper read before the Physical Society, Professor Hughes describes the "Physical Action of the Microphone" as the introduction into the circuit of an electrical resistance, which varies in exact accord with sonorous vibrations, so as to produce an undulatory current from a constant source. The undulations in length, height, and form, are an exact representation of the sonorous waves. It is essential that the instrument be so arranged as regards pressure between the touching surfaces as to be adapted to the particular vibrations employed. Thus a box suitable for a man's voice is not adapted to observe the tramp of a fly. When speaking, a galvanometer should be interposed in the circuit, and the pressure between the surfaces gradually increased from a minimum until the needle remains stationary, when a maximum loudness will be attained. In the experiments illustrating the paper, a small clock being placed on a drawing-board carrying a microphone, and made to interrupt the current passing through a telephone, the tick was audible throughout the room. The telephone being provided with a bell-mouthed tube, enabled the sounds to be heard at a distance. A second telephone was then introduced into the circuit, and laid on the board, a continuous sound being at once produced. Thus a relay for the human voice could be obtained; for it is only necessary to provide such an arrangement at each station for a speech to be received and transmitted to any number of succeeding stations. The system is perfectly duplex, for if two correspondents speak into microphones, and use telephones in receiving, each can hear the other, but his own speech is inaudible, and if each sing a different note, no chord is heard.

Messrs. Edwin Houston and Elihu Thomson, writing from the Central High School, Philadelphia, to "Nature" (June 28th), describe a "Telephone Relay" or "Repeater," which consists in applying the microphone directly to the diaphragm of the receiving telephone; the two fixed pieces of carbon being cemented to the diaphragm itself, and the third piece placed in cavities near their ends. The microphone forms part of the new circuit in which it is desired to repeat the message.

From some experiments on the *Influence of Temperature on the passage of air through capillary tubes*, Dr. Francis Guthrie concludes:—

(1.) That the time varies approximately as the square of the absolute temperature.

(2.) That the variation of the time deviates from the law of squares by a term approximately proportional to the temperature.

(3.) That the formula connecting the time and the temperature is nearly

$$t = d\mathrm{T}\ (\mathrm{T}+\beta)$$

where T is absolute temperature reckoned from — 273° C., and β seems to depend on $p_1 - p_2$ or the difference of pressures, the exact relation not being obvious.

Thermo-Electric Currents in Strained Wires have been investigated by Mr. G. W. von Tunzelmann. The object in view was to determine the conditions under which thermo-electric currents are produced in a circuit composed of a single metal, when one portion of the metallic conductor is subjected to a strain, and the strained and unstrained portions are maintained at different temperatures.

"Two tin cans were obtained, open at the top, and pierced at the bottom by necks, into which India-rubber corks were inserted; through slits in these the wires were passed. The wire was fastened by a clamp in the lower can, and grasped in the upper by a pair of wire-drawing dogs attached to the shorter arm of a lever, to the longer arm of which was attached another tin can, open at the top, and having at the bottom a neck fitted with an India-rubber tube, which could be closed by merely bending it up and hitching it in a hook attached to the can for that purpose. The strain on the wire was then produced as gradually as possible by pouring in measured quantities of shot. It could be removed as gradually by letting the shot run out by the India-rubber tube.

"The two cans through which the wire passed were kept, one at 100° C, the lower, at the surrounding temperature by a stream of water.

"The ends of the wire were connected with a Thomson's Galvanometer.

"As the strain was increased the current was increased, but only up to a certain limit. When it was carried beyond this point there was a gradual decrease in the current. If the strain was very carefully increased the direction of the current was reversed shortly before the breaking strain was reached."

Ten such experiments are recorded, from one of which a diagrammatic curve is obtained.

On the pitch of a tuning-fork in an incompressible fluid, by Felix Auerbach. When a tuning-fork is plunged in water, a note, not agreeing with that in air, is given out, the dissipation of kinetic energy taking place in incompressible fluid differently from that occurring in air. The tone becomes deeper in the ratio $\sqrt{1{\cdot}4} : 1$, *i.e.*, as 1·18 : 1, or about as 7 : 6, more, therefore, than a tone, and less than a minor third.

The fall in pitch was determined by means of beats between a fork immersed in water and another, of a tone lower, in air. It appears that the resistance of liquids depending on density and viscosity does not come sensibly into consideration as regards wave lengths, though it does as regards

amplitudes. This is true of mercury and glycerine, though the former is of high density, and the latter of great viscosity.

Experiments with Floating Magnets, made by Alfred M. Mayer, show the motions and arrangements of freely moving bodies acted on by forces of attraction and repulsion.

A dozen sewing needles, magnetized with their points of similar (N) polarity, are run into small corks so as to float upright in water, with the eyes above the surface.

The north pole of a large cylindrical magnet being brought down over them, they arrange themselves as an equilateral triangle. Four needles form a square, or an equilateral triangle with a central needle. Five form a square with centre, or a pentagon; six a pentagon with centre, or an equilateral triangle of six points arranged quincuncially; seven form a regular hexagon with central needle, and so on.

Floating needles may be used generally as delicate indicators of magnetic actions, such as the position of poles, and the displacement of lines of magnetic force during inductive action, or, for instance, in the telephone.

ZOOLOGY.

Aerial Respiration in Fishes.—Professor Jobert, of Dijon, who is now engaged in making some zoological investigations in Brazil, at the instance of the Emperor Don Pedro, has ascertained some exceedingly remarkable facts in connection with the respiration of certain fishes. A Siluroid fish, which inhabits the neighbourhood of Rio de Janeiro (*Callichthys asper*), and is noted for its power of living a long time out of the water, was found by him to swallow small portions of air, from which it partly absorbs the oxygen by the agency of the walls of the intestinal canal, the carbonic acid formed, and the unabsorbed nitrogen passing away by the anal aperture. On examining the structure of the intestine, Professor Jobert found its inner surface bearing a multitude of filiform appendages arranged in tufts, and composed essentially of blood-vessels.

A somewhat analogous case was observed in several other fishes inhabiting the valley of the Amazon. They live in stagnant water, the temperature of which often exceeds 104° F.; but this does not appear to be sufficient to support their respiration, and they are obliged to come frequently to the surface for a supply of air. Sometimes, also, the water in which they have been living is dried up, when they are seen making considerable journeys by land in search of more favourable localities, crawling on the ground by means of their pectoral fins. Some of these are species of *Callichthys*, and, like the *C. asper* of Rio de Janeiro, they possess a double respiration,—respiring the air contained in the water surrounding them by means of their gills, and also the atmospheric air which they swallow, and which passes through their intestine. The escape of the exhausted air from the anal aperture in these fishes is said to produce a constant bubbling in the water they inhabit, and M. Jobert's investigations, though imperfect, sufficed to convince him that the air evacuated contained much carbonic acid, and less oxygen than atmospheric air. The vascular tufts clothing the wall of the intestine originate from

adjacent veins, in the same way as the afferent vessels of a lung. Species of *Doras* and *Hypostomus*, inhabiting the Upper Amazon, respire air in the same way as the *Callichthyes*, but in the *Hypostomi* the used air is returned towards the mouth, and escapes by that orifice or by the branchial apertures.

In *Sudis gigas* and some species of *Erythrinus* aerial respiration takes place by the agency of the swimming-bladder, which, in the latter, has long been known to communicate with the outer world through the œsophagus, and to be furnished internally with numerous cells formed by membranous folds. Professor Jobert finds that the walls of the swimming-bladder, including all these folds, are richly provided with blood-vessels, mostly originating from the venous system, and that it is thus converted into a true lung, by the possession of which the fishes are enabled to live for a long time out of the water. Of the reality of this respiration, Professor Jobert convinced himself experimentally by obstructing the air-duct leading to the bladder; the fish soon died by suffocation. These observations are particularly interesting as establishing further bonds between the true fishes the Lepidosirens, and the perennibranchiate Batrachians, which possess at the same time branchiæ and true lungs.—(*Comptes rendus*, April 15, 1878.)

A New Tubicolar Annelid.—The late Professor Claparède described certain small Annelids as stages in the development of the well-known *Terebella conchilega*. M. Adolphe Wartel, a pupil of Professor Giard's, detected what appear to be the same Annelids attached to the branches of the common Campanularian polype, *Laomedea gelatinosa*, where they inhabit small projecting transparent tubes, so exactly resembling the gonothecæ of the polype, as easily to escape detection. The presence of generative products in many of them proved them to be adult forms, and not young stages of any *Terebellæ*; and Professor Giard establishes a new genus and species for this interesting little Annelid, which he names *Wartelia gonotheca*, the generic name commemorating its discoverer, the specific alluding to the curious mimicry of the gonothecæ of the Hydroid which its tubes present. It is remarkable for the presence of large otocysts like those of mollusca and for certain peculiarities of the ventral cirri, which lead to its removal far from the *Terebellæ*.—(*Comptes rendus*, May 6, 1878.)

Circumspection of Ants.—Professor Leidy gives somes curious details concerning the little red ant which seem to show that this insect is capable of becoming circumspect by experience. When he purchased his present residence, and while it was undergoing some repairs, he noticed a piece of bread, left by a workman in one of the rooms, swarming with ants. Fearing that the house was seriously infested by these insects, which, when numerous, are great pests, to ascertain whether it was so he placed a piece of sweet cake in every room from cellar to attic, and at noon every piece of cake was covered with ants, and each piece was carefully picked up, and the ants tapped into a cup of oil of turpentine. The cake was replaced, and in the evening was found again covered with ants. The same process was repeated morning, noon, and night for the next two days; on the third day the number of ants was greatly diminished, and on the fourth there were none. Professor Leidy at first supposed that all the ants had been destroyed, but in the attic he observed a few feasting on some dead house flies, which led him to the conclusion that the remaining ants had become suspi-

cious of the sweet cake. He accordingly distributed through the house pieces of bacon, which were soon swarming with ants. This was repeated with the same result for several days, when the ants finally ceased to visit the bacon. Pieces of cheese were next tried with the same results, but with an undoubted thinning in the multitude of ants. When the cheese no longer proved attractive, recollecting the feast on dead flies in the attic, dead grasshoppers were supplied from the garden. These again proved too much for the ants; and, after a few days' trial, neither grasshopper nor anything else attracted them: they appear to have been thoroughly exterminated, nor has the house since been infested by them.—(*Proc. Acad. Nat. Sci. Philad.*, 1877.)

A Pigeon Living without a Brain.—Dr. McQuillen described before the American Philosophical Society (Feb. 1, 1878), a case of the extirpation of nearly the whole of the cerebrum of a pigeon, operated upon by himself. He desired to place on record the fact that the animal not only survived the operation twenty-four days, but that it gradually regained its usual powers and habits of flight and its ability to feed itself and drink. Only one other such case is on record.

The Turbellaria of the Deep Waters of the Lake of Geneva.—M. Duplessis finds that, with two exceptions, all the species of Turbellarian worms from the bottom of the Lake of Geneva are also found in the stagnant waters of the shores, or in the marshes and small lakes of other parts of the canton, but that most of the species have undergone some modifications. Thus specimens of the Planarians *Dendrocœlum lacteum* and *fuscum*, from the deep waters, are generally smaller and lighter in colour than those found in shallow water, and have the digestive tube of a rosy tint. The visual organs tend to become atrophied; but one variety of *Dendrocœlum lacteum* has each eye-spot divided into two smaller points, and has been described as a distinct species under the name of *Planaria quadrioculata*. *Microstomum lineare*, a Rhabdocœlan form, becomes larger, and has the intestine of a pale rose colour when living at the bottom of the lake.

The two exceptions above mentioned are very remarkable ones. While the rest of the deep-water Turbellarians all belong to the neighbourhood, these two species, which have been named *Vortex lemani* and *Mesostomum morgiense*, but which probably represent new genera, resemble Mediterranean types, and the second belongs to a group of Turbellaria hitherto regarded as exclusively marine. These two forms, which have been found in one or two other European lakes, are among those which descend to the greatest depth.

As analogous phenomena M. Duplessis refers to the occurrence among the Crustaceans of the deep fauna of a form related to the marine genus *Cythere*; and states that he has himself obtained two species of Arachnida (mites), closely related to marine forms. One of these is a *Campognatha* (*C. Forelli*) which so nearly resembles a small species found on the shores of the Mediterranean, that the two might easily be confounded; the other belongs to a genus hitherto known only from the Mediterranean. These facts are exceedingly interesting and important, in connection with other observations which seem to prove the survival in the deepest waters of lakes of a residue of the old marine fauna which once occupied them. *Univ., Arch. des Sci.*, Oct. 15, 1877).

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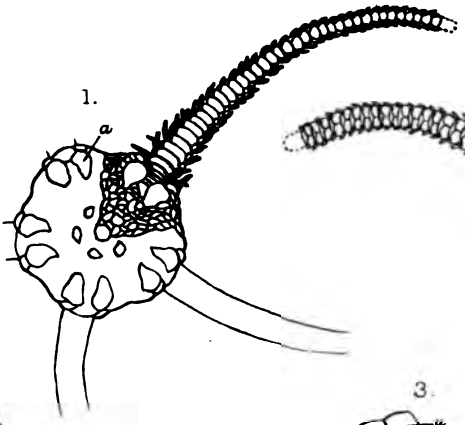
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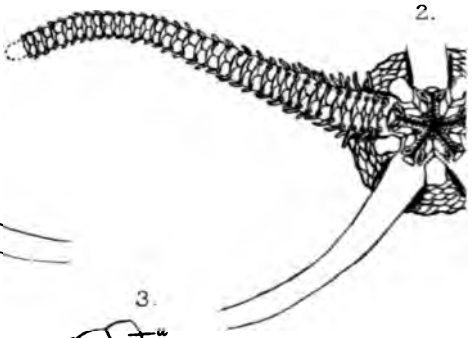
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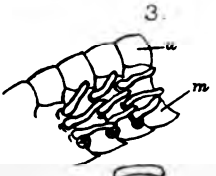
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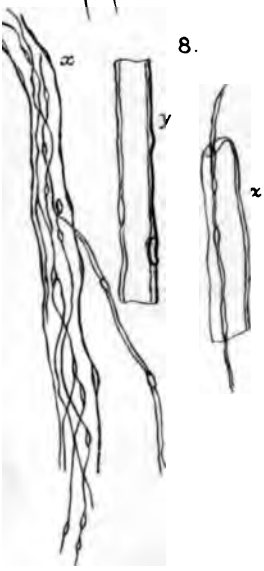
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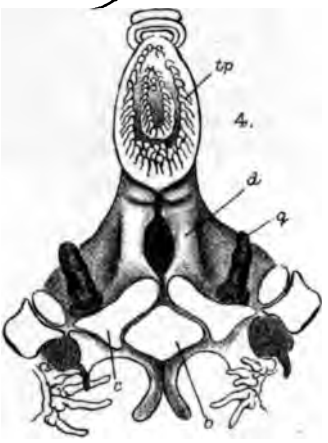
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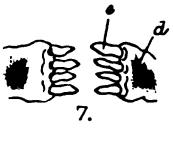
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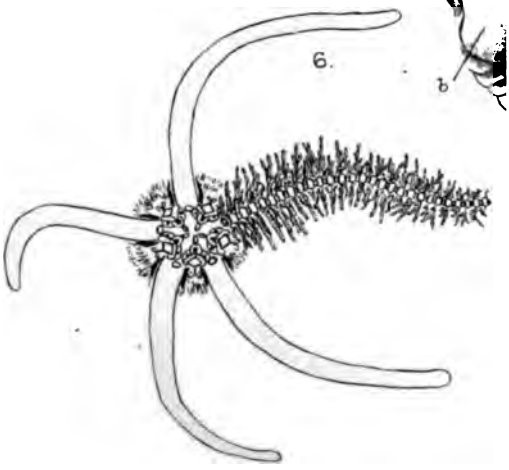
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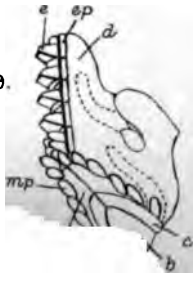
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NOTES ON THE OPHIURANS, OR THE SAND AND BRITTLE STARS.

By Professor P. MARTIN DUNCAN, M.B. (Lond.) F.R.S., &c.

PLATE VII.

HE marine invertebrata, which are called Echinodermata, on account of their possessing a more or less perfect covering ometimes spiny, and usually geometrically shaped pieces of onate of lime, form a very large and natural group, which ery well defined on one and not so perfectly on the other of the zoological scale.

uvier made the Echinodermata to form a class of the sub-gdom Radiata, and Agassiz insisted on retaining this nomen-ure, which is still employed by some excellent naturalists. star-like markings and form, the arrangement of the ctures in a raylike manner around the mouth, and the umed absence of any two-sidedness, apparently so character- of the sea-anemones, corals, jelly-fish, and Echinoderms, lered the Radiate sub-kingdom very readily separable from worms on the one hand, and from the shapeless lower animals he other. Like other abstract matters, classificatory zoology its phases, grooves, fancies and fashions, although its solid ress depends on a correct balance of embryological and phological learning under the influence of a method of cious comparison.

here is no doubt that the Radiata were made to include e groups of creatures whose classificatory union was in-ruous, and that those possessing a radiate form were ciated with the shapeless, and this necessitated the limita- of the sub-kingdom. Then Leuckart, acting under a lively osophical impulse, insisted, from the study of the structures me of the most important Radiata, that they were positively "all round creatures," but were two-sided or bilateral. The inodermata were shown not to be truly Radiate animals, and nade a special group of them. The Actinozoa and Hydrozoa separated from the Echinodermata by their gastric liarities, and their cavity with a sole entrance—their hollow el—gave them the name of Cœlenterates. Broken a Radiate sub-kingdom became a republic, and the

Echinodermata began to seek outside alliances with the worms, just as the Cœlenterata are now anxious to annex the Spongida.

As long ago as the days of Edward Forbes, when the Radiate sub-kingdom was flourishing, that great naturalist paved the way to a late favourite zoological development. In treating of one of the great divisions of Echinodermata, the Sea Cucumbers, or Holothuriadæ, he introduced a group of creatures which he called Vermigrade Echinodermata, such as the shell-bearing *Sipunculus* and the Spoon Worm. He wrote, "In the animals of which we have now to treat, Radialism sets and Annulism appears. In their external appearance they are worms, for the likeness they bear to the Holothuriæ (Sea Cucumbers) depends on a correspondence with the vermiform and not the radiated character of those animals; but internally they afford evidence of belonging to the same great class. They are in fact Annelidous Radiata." This idea bore fruit, and set a fashion, and the attempts to unite the Echinoderms with the worms, gave way to attempts to make worms of the whole set. The Sipunculidæ and their allies were, however, put into the Vermes, and now rank as Gephyrea; but other discoveries led the urchins, five-fingered jacks and their fellow hard-skins within the domain of the worm for awhile.

The embryology, or rather the changes of form of the young Echinoderms, was studied by Müller. And it became evident from his admirable work, that not only was the Radiate type non-existent in the early stages, but that there was then an evident two-sided symmetry; the young stage approaching, for a time, the immature forms of some worms. The alliance of the Echinoderms with the worms was not, however, left where Forbes placed it. Naturalists insisted on the union of the two groups, and thus the hard-skins were, for a time, united to a very disjointed group, possessing all sorts of anomalies of structure on account of so many of its members being parasites. Commonplace naturalists did stare when such things as wheel animalcules and tape-worms were united; but having got used to it, they ceased very much to wonder when Huxley united these and the whole of the Echinodermata in a *primary category* of the animal kingdom under the head Annuloida. All have a water-vascular system, there is two-sided symmetry in all, and their ciliated larvæ are not without resemblances. Macalister, of Dublin, however, says, "the Annuloid arrangement is a convenient though unnatural grouping, as the Echinoderms are Deuterostomes, whilst most of the worms (Scolecids) included in Annuloida are Archæostomatous." The meaning of this appears to be, that in these worms the original embryonic mouth remains during life, but that in the Echinoderms, this original opening having served its purpose, does not

remain, and another is formed during the metamorphosis—a statement open to very considerable question. Years rolled on, and nerves, which once gave the clue to classification, became of as little importance as water systems, and stomachs reigned supreme as zoological guides. And Haeckel, faithful to his stomach as a zoological loadstone, noticing that in Star-fish the viscus is carried into each ray, infers that the animal is a colony of worms, united by a common head. Leaving this stroke of genius for what it is worth, it is simply necessary to remark that the last and the most remarkable phase of thought, separates the Echinodermata from the worms and Cœlenterates, and establishes them as a sub-kingdom divided into classes and orders. The classes are the Crinoidea, the Asteroidea, the Echinoidea, and the Holothurida; and the orders of the Asteroidea are the Asterida or Star-fish, and the Ophiurida, these last being divided into the sub-orders Ophiuræ and Euryaleæ.

The great fault of this classification is, the too close union of the Star-fish and Ophiurans, for these last differ very considerably from the others in their embryology, and require a class of their own.

Everybody who has visited the seaside, has seen a Star-fish and a Sea Urchin; Sea Cucumbers are common in every aquarium of importance; and what are scientifically called Ophiurans, and popularly Brittle Stars and Sand Stars are to be seen dried, or in bottles, in every museum. Sometimes these last are seen as waifs and strays on the shore, and perchance on cleaning a cod's stomach they may be turned out by the score. The most unobservant know all these things at a glance. They have something very decidedly in common, except the Sea Cucumbers, which links them together, such as the hard and somewhat spiny shell, the feelers by which they move, and the rayed appearance, and the youngest zoologist would classify them together. There is another group of these hard-skins, beautiful in shape, elegant in movement, and often dwellers on the floor of the deepest seas; but these, the Feather Stars or Sea Lilies, are not so well known except to naturalists by education.

It is interesting and also somewhat important, in examining into the life history of these groups to know that they are all very old dwellers in the seas. Very early in the world's history there were Feather Stars (*Crinoids*), Star-fish (*Asteriadæ*), and Sand Stars (*Ophiurans*); the Urchins (*Echini*) came a little later, but still in the palæozoic ages, and there are relics of the Sea Cucumber series in the Carboniferous rocks. No very great amount of structural change has occurred, as a whole, in the group since palæozoic times, and the types were thus distinct ages ago—that is to say, in Silurian times the Star-fish and

Ophiurans were in existence, and attention is directed to this fact, as it is with the class of Ophiurans that this communication deals.

There is no mistaking an Ophiuran, for its round flat body and its five slender plain or spiny arms, the whole as a rule being scaly and of many colours, distinguish it from all other things. They are of very different sizes when full grown; in some the body is an inch and a half across, and in others not more than a few lines. In most, the contour of the body is circular and flat, but in some it is pentangular, and it may be tumid or even constricted between the arms. These last vary, wonderfully, in their size, shape, construction and ornamentation, and in some instances the number five, so peculiarly characteristic of the Echinodermal structures, is departed from, and six arms exist. Moreover, it is by no means certain that some kinds have not different numbers of arms, at different periods of their lives. The top and sides of the body, are either covered with a skin, or else with geometrical plates or scales united at their sides or overlapping; they are often more or less covered with granules, little spinules, and even with groups of spines. Black, red, yellow, green, white, brown, and grey, either pure or in all sorts of tints, are common colours in the skin and spinules, and the plates are splashed with the same colours. The colour may be universal or in parts, especially in rings on the arms, and in some instances the reptile-like look of the body and arms is maintained by a square brown or white pattern greatly resembling that seen on many Ophidia. The plates are often arranged in beautiful patterns, a rosette being central with radii of plates in the space between where the arms fit in to the upper part of the body in a sort of notch. And as the plates vary in size as well as being in squares, hexagons, pentagons, and rectangles, every opportunity is given to Dame Nature's love of organic æsthetics. Close to where the arms come in, on the top, there is usually, but not invariably, a notch for them, and between it and the centre are certain plates which are constant, but are sometimes hidden, being covered with skin. Two of them are found on either side of the track of the arms, and not far from the margin or edge of the body above. They are called Radial shields, (fig. 1, *a*) and as one is on either side of the arm they are in pairs, there being five pairs in all, and six when there are six arms. On either side of the arm notch, or even nearer the centre of the upper surface, these ten plates give a character to the animal, when they are well developed.

The sides of the body are between the arms, and are usually scaled or plated, being spinulate or not. In some they are naked, that is to say, covered with skin which has little carbonate of lime the form of scales or plates. When the animal is placed

on its back the under part of the body presents itself, and its middle is very pretty-looking, and very geometrical, from the quintuple repetition of regularly-shaped plates converging to the central mouth. Between the elements of this quinary arrangement are the lower parts of the arms, which come well within the body like so many radii, and reach to the slits which surround the mouth. Each arm in its radial course confines a portion of the body between it and its neighbour, and the space is limited, without by the edge of the body (the margin), and within by some plates which point to the mouth. This space is an interbrachial space, and on it, close to the arms, are slits or linear openings, one on either side usually, but in some kinds two. These lead upwards, in the proper position of the animal, into cavities—the generatives. Sometimes the interbrachial spaces are naked, but in most genera, they are covered with a less regular and smaller plating or scaling or spinuling than the upper part of the body. At the inner angle of each interbrachial space is a plate, one of which is sometimes porous, called the mouth shield (Figs. 2, 4, and 10 *b*). Within it, that is to say, nearer the centre, or, as the term is, "orally," are two smaller plates (Figs. 4, 9, 10 *c*) called side-mouth shields, and orally or internally to them is a more or less triangular mass, fringed at the free sides and tip, (Figs. 4, 9 *d*) with a few or many papillæ. Careful examination will show that the triangular surface is divided by a line running nearly from the apex to the base, and really there are two triangles side by side. These are the under surfaces of the jaws, and at their apex the innermost papilla is upon a small plate, the under part of which is seen from below, and it is called the jaw plate. A different view explains that it runs up into the body, fixed on to the jaws, and that it supports some projections called "true teeth." There are five of these jaw arrangements, each of which is called "an angle," and the roots, so to speak, of the arms fit in between their bases between neighbouring mouth shields. (Figs. 2, 4, 9 *d*, jaws; *e*, teeth; *e p*, jaw plate).

The arms, whether long or short, spiny or nearly plain, are composed of an outside of more or less regular plates, and of an inside support. They must be tolerably strong, more or less protected, able to move, and, oddly enough, capable of being separated here and there, and cast off, to be again repaired. Their conformation relates to the habits of the animal, and as some Ophiurans wriggle them much horizontally, and indulge in serpentine and interlocking movements wonderful to behold, they must have the scales on the arm arranged to permit of this, especially as in these instances long spines stick out from the sides of the arms. Such arms are of necessity not capable

of much upward or downward movement. It is somewhat remarkable that although many of the species have arms many times longer than the bodies are broad, and they seem to be of the greatest possible importance to them, still they are not only readily broken by accident, but even cast off joint after joint, piece after piece, until only the body is left. These kinds have the very good name of Brittle Stars. Other Ophiurans have small spines on the arms, have not so much horizontal and about the same amount of vertical movement as the others, and their power of casting loose their own segments is less. These are the Sand Stars. Both kinds have the arms in numerous joints, each of which consists of four plates. One is above—the upper arm plate; one is below—the lower arm plate; and one on either side, and encroaching more or less above and below (or not at all), the two side arm plates. The plates get smaller and smaller towards the narrow tip of the arm, and the whole member consists outside of a repetition fore and aft of these four plates. Sometimes skin exists instead of some plates or parts of plates, and the successive plates are united by skin to their neighbours. The plates are not very thick, and form, as it were, a tunnel, wide, close to the body, and narrowing at the tip, where it is closed. There is a central support running down inside the arm, which can be seen when an arm is broken across, and certain openings in the arm outside have to do with it. The openings are on either side of each lower arm plate, and between it and the side arm plate on either side, and they are for the passage outwards from within of feelers or tentacles. The arms are flat below, where covered by the lower arm plate, rounded, and more or less tall at the sides, where the side arm plates and the spines are, and rounded or roof-shaped above, from the presence of the upper arm plates. It must be remembered that the tentacles come out below at the sides of the lower arm plates; and they are protected by a little scale or scales, which may be on the side arm plates, or on the lower arm plates, or on both. On looking at the mouth of a living Ophiuran, four longish tentacles will be seen in each slit which is between two mouth angles, and two belong to the jaw of each side of each angle, so that every jaw has four, or two on either side. One is higher up in the jaw than the other, and they are protected by tentacle scales more or less large. (Figs. 4, 9.) The passage between the teeth leads to the stomach. One of the group in lively movement is a sight to see; the muscular energy is marvellous, and this is especially the case with the Brittle Stars. A Sand Star may be seen crawling over things in the aquarium, moving its arms not very much, but using the numerous pairs of short active tentacles a good deal. They [illegible] suckers at the end, and they are not attended by care-

ful pinching pedicellariæ as in the Urchins and Starfish. They do not help the star much in climbing up glass or weed, but they appear to be extremely sensitive to touch, to the presence of foul water, and of nice things. The large tentacles of the mouth angle spaces move much, and evidently direct food to the mouth, and when a soft bit of oyster is given to the animal, it being permitted to touch one of the arms, this is moved towards the mouth, and the mouth towards it. All the tentacles are expanded to the utmost, and the morsel is pressed against the mouth and gradually disappears, the opening between the teeth becoming slightly wider; after awhile, the part of the food which cannot be digested is returned. They know what is nice, and can therefore taste; they are vivacious after a good meal, and therefore digest comfortably; their tentacles enlarge and contract, and the arms and body grow, therefore there must be a circulation and processes of nutrition. They have more than a rudimentary nervous system, but eye specks or visual organs are deficient. They soon die if their respiration is not well kept up; and as this is mainly done by the tentacles and their internal machinery, a curious self-mutilation accompanies impaired respiration. The arms are cast off at joint after joint, as the water becomes more and more impure. The Brittle Stars drop their arms, which continue to wriggle for a time very readily; and the process of repair seems to be pretty rapid, for new arms or pieces soon grow again.

It is now necessary to consider some points in their anatomy and physiology a little more closely.

If the skin and scales of the middle of the upper part of the disc be carefully cut through and raised with a pair of forceps, a membrane will be found beneath them, and attached pretty firmly in some places and less so in others. The membrane is the upper part of the stomach; and if it be opened, the inside of the organ is seen, and quite low down there are five whitish bodies projecting inwards towards a common point (fig. 5, *d*, *e*). These are the upper five teeth, one on each jaw, *e*, and the upper surface of the jaw plate and jaws is seen (fig. 9, *e*, *ep*, *d*). An opening exists between the approximating teeth centrally, and it leads to the lower surface of the animal, or to the lower opening of the mouth. The teeth stand out well, and the membrane of the stomach is not attached to them, for it encircles the whole jaw arrangement a little further out than the attachment of the jaw plates to the jaws (fig. 5, *s*), and passes over the space between the angles. The stomach is in the shape of a wide-mouthed bag, which has no other opening than that of the so-called mouth, and it does not fill the body, nor is it, as in the star fishes, found in the arms. It is attached to the under surface of the skin of the upper part of the

body, and also along the circular line on top of the jaws, and this last adhesion is not broad but almost linear (fig. 5, *s*).

Leathery in spirit and water, its structures are not then readily distinguished; but a fresh Ophiuran's stomach membrane is semi or quite transparent, and yields some interesting points to the microscope. There is a muscular coat, consisting of sets of separate fibres, unstriped and sometimes branching, which radiate from many centres. Those of one locality join on to those of another, and form a series of close meshes. The fibres are distinct, delicate, and are outside a mass of cells, which are spread out as an indefinite membrane, and are ciliated. The cilia are numerous, small, and are readily cast off with their cell. It would appear that, although the lower limit of the stomach around the mouth within, is an irregular circle made by the jaw plates and the sloping sides of the jaws (producing five re-entering festoons and loops external to the jaw plate), there is a film of probably ciliated membrane passing down between the angles to the surface. But really the entrance to the stomach is central only, and not also between the side of each jaw angle. The teeth form five buttresses around the opening. The large tentacles in each angle are muscular, tubular, and ciliated, and they come out of the jaws by holes, one of which is nearer the stomach than the other. They fill up the angle greatly, and as they move radially, they assist the food in entering, and expel undigested matters, and, as Forbes wrote years since, they are in constant movement. Water passes readily into the mouth and stomach, when the teeth, set in longitudinal series on to the jaw plates, are slightly removed from each other (fig. 7, *e.*); but when they touch by their points the passage cannot be free. The question arises—Do the vertical true teeth act as chewers? By what structures do they approach and regress in order to chew? Mr. Lyman calls the five angles of the mouth and the supported teeth the chewing apparatus. We distinguish between biting, masticating, and chewing: the last term relating especially to the particular lateral movement used by mammals, and to a constant movement, in which the teeth are not much separated, and which is used by man to enjoy tobacco.

There is evidently no lateral movement in the angles of the jaws, and that which is directly to or from the central or axial line of the vertical mouth, must be very slight. It would appear that the jaw plate is made up of more than one piece, although this is by no means always to be seen, and the teeth which it supports on its inner face (figs. 9 and 7, *e*) are said to be connected to it with muscular fibres. Microscopic, indeed, are they, and they can only relax and contract and fix the teeth laxly or rigidly to the jaw plate. Their power of assisting biting

or crushing is hypothetical. The tooth papillæ (fig. 4, t.p.), which in some genera form a symmetrical group close to the lower margin of the jaw plate, merge gradually into five teeth above. They cannot act as crushers, and indeed in many species those of the five angles are widely separated below, so as to form a funnel-shaped opening to the mouth, leading to the narrow space above, where there may be only two or three teeth on each plate (fig. 4). Lately Danielssen and Koren and myself have described species in which the true teeth are divided, pointed, and irregular, and yet the Ophiurans were invariably large and well nourished. There is no rule about the closeness or open condition of the mouth canal between the jaw angles after death. In some specimens the teeth are in apposition, and the mouth papillæ (fig. 9 *m.*, *p.*), nearly close the sides of the angles; but in others it gapes and *rigor mortis* fixes it slightly open. Moreover, small Lamelibranchs, as I have lately had an opportunity of finding, get into the stomach, but their delicate valves are not crushed; and Foraminifera are to be found there, comparatively uninjured, besides much mud. The masticating and chewing does not take place. The mouth papillæ, situated on the sides of the jaw angles (fig. 9, m.p.), are evidently filterers, and so are the tooth papillæ. The true teeth keep out trespassers from the stomach, but none of them are used to crunch or smash nourishment, and the wonder is how the creatures manage to poke good-sized pieces of oysters into their mouths. The tentacles within the angles are of immense importance in this proceeding, and it is very conceivable that the usual and normal food is finely triturated mud, containing minute organic bodies. It is clear that in some species the moving outwards of the jaw angles from the axis must be of the slightest description; for the mouth apparatus is rendered unyielding in them, by the side mouth shields being united under the arm in a continuous zone. On the other hand, some extra limit may be granted by the non-union and generally rudimentary condition of the side mouth shields in some genera. Possibly some movement of the jaws towards each other centrally, may occur, first above and then below, and it is conceivable that movements of the arms from side to side, and from above downward, rare as these are in some kinds, must contribute to slight movements in the jaws. Some kinds, however, keep their teeth closed in spite of great wriggling. In fact, the more the matter is examined into, the more difficult it is to understand, not only how the Ophiuran bites and chews, but how it bolts a morsel; and certainly it does this last performance, whatever doubt there may be about the first. The stomach has some fibres, both longitudinal and circular, and some are close to the line where it is attached in festoons, above and external to the

teeth; and the animal, when it gets anything eatable near its mouth, probably relaxes its stomach muscles, and stuffs the morsel down with its arms and mouth tentacles. They must, in some instances, swallow mud in large quantities—mud containing organisms with calcareous shells, and I have found Foraminifera in the stomach. Forbes,* in noticing the result of digestion, writes with regard to the tentacles: "They are continually in motion, moving up and down; and every now and then when the stomach pouts up and ejects some digested matter, the inner tentacles shovel it up, and the outer clear it away. This is done with great regularity, and it is a very curious sight, for not only are the motions and actions of the tentacles admirable; but when the stomach swells, there appear bright orange stripes of a most vivid metallic lustre running along its surface with an almost phosphorescent gleaming." These remarks refer to the common Sand Star.

The ciliated surface of the stomach is secretive also, and from it must come the weak acid juice which dissolves the protoplasm and organic matters of the food, with some pepsin or other. The corroding influence is seen in the minute shells found in the stomach, and thus a digested pabulum with some salt of lime is manufactured. It is destined to nourish the animal's soft and hard parts to the remotest arm tip, to replace albumen and fibrine, refractive matter, chitinous fibre, and worn-out carbonate of lime of the skeleton, and to be placed in definite positions during growth. It has to be circulated everywhere, and the worn-out matters have to be got rid of from the tissues. Substances which cannot be digested are of course simply removed through the mouth; and as perfect closure of the mouth cannot prevail for any considerable length of time, much water must find its way into the stomach. Doubtless the chyme, if it may be so called, is much diluted, and it is wafted over the inside coat of the stomach over and over again by means of the cilia, but, beyond believing that it may enter stomach cells and pass from one to another, the imagination fails to assist in the elucidation of the problem, especially if it is centred in the belief in veins, arteries, and lymphatics as inevitably necessary physiological adjuncts to nutrition. Some amount of churning may go on in the stomach during digestion, for the muscular fibres are numerous, and are of the kind which is associated with involuntary rhythmical movement; and this alternate contraction and relaxation may assist in the movement of the nutrient plasma in and through the cells. The process must be of the simplest kind, and this is an important consideration, for digestion is much more complicated in the Echini and Star-fish, which are associated with the Ophiurans in classification.

* Forbes, "A History of Star-fishes," p. 24.

There is a plan which I have adopted in investigating the rough anatomy of the Ophiuræ, which may be of use to other investigators, especially if they have time to follow out the structural details which are rendered manifest by it. Get a small specimen of *Ophioglypha*, and put it in weak hydrochloric acid and water, 1 in 100 at first, and then 1 in 20, washing often in clean pure water. Too much bubbling must not be allowed, for it destroys the tissues, but if the solution of the carbonate of lime proceeds steadily and slowly, a very remarkable preparation may result. It is difficult to get rid of all the carbonate of lime, especially from within the arms, but sufficient may be dissolved to give capital views of the anatomy.

One detail soon becomes evident on the under surface of the animal, and that is the lower limit of the stomach. Turn the preparation on its proper upper surface, and examine the lower by transmitted light, and a wide circle of tissue is seen hidden more or less, by the transparent tissue which was once jaws. It fills up the slits between the angles nearly to the level of the jaw plate, and there is no passage there into the side of the angle. On this lower surface of the stomach, or in the proper position of the animal under it, but close to its attachment to the jaws, is a canal or tubular membrane. It can be seen to give off branches, and to make its way as a microscopic tube into the arms, running in the median line on the under surface beneath the lower arm plates, which are of course all dissolved away, so far as their mineral part is concerned. It is a circular tube surrounding the insertion of the stomach into the jaws at a little distance and branching for every arm. In a little *Ophioglypha*, the body of which is less than $\frac{1}{3}$ inch across, the tube is about $\frac{1}{300}$ inch in diameter after the acid treatment. The tube has swellings on it called Polian vesicles. In the instance before me, a short membranous tube leads from the perforated or madreporic mouth-shield to a globose enlargement, whose diameter is five times that of the tube, and a corresponding tube makes its exit on the other side and then slants off to the circular tube, which it joins. This is the feeder with water, from without; and in its passage from the mouth-shield to the circular tube, it runs upwards and slightly inwards between the root of two arms and outside the stomach membrane, and between it and a membrane about to be considered, and which has to do with the reproductive organs. The swellings or Polian vesicles on the circular tube, usually said to be four in number, are simple enlargements of its muscular walls, with a slight increase of calibre on one side of the axis of the tube, and they are found close to the position of the off-giving of the radial vessels of the arms. In the specimen of *Ophioglypha*, the tube is pentagonal and not circular in direction,

and the swelling on the madreporic tube, replaces the fifth Polian vesicle. The whole is as unlike the drawings given in text books as is usual in cases where a diagram is reported to be a truthful representation of nature. Moreover the canal is closely invested by other structures, and when full and in action must have contained a very minute quantity of water. It is said to have an internal cellular layer which is ciliated, and one can envy the eyes which saw this very probable fact.

Between this more or less circular canal and the circular attachment of the stomach, is a ring of nerve which rests on the jaw close to where there is a suture or join between the stout or inner part of the jaw and the narrower portion, to which is attached the jaw plate. As a matter of fact this nerve is external to the stomach attachment and slightly above it, and it is internal to and below the circular tube. What modifications age may make I do not know, but that is the position in the young.* The closeness of the water- and nervous systems is of importance, especially if the circular tubular canal acts as a blood circulator as well, which is excessively probable. In order to understand the course of the branches of the circular water canal, a few words must be said about the jaws, to which allusion has been so frequently made. As already noticed, their under surface is seen internally or orally to the side mouth shields, and two are placed together in each angle, their sides supporting the mouth papillæ and their inner end the jaw plate and its tooth papillæ and teeth (figs. 4, *d.*, 7, *d.*, 9, *d.*). The upper surface can be seen by removing the skin of the upper part of the disc and opening the stomach (figs. 5 and 9). The jaw plate and its teeth are seen to be attached to two rather diverging pieces, and these are the upper part of the pair of jaws of the angle, rather separated externally. Still further out, the separation increases, and an irregularly triangular piece is connected internally with the short diverging jaw, and is called the jaw or mouth frame. The mouth frame, one to each jaw, unites on one side with the mouth frame of the jaw of the next angle, and on the other, does not unite with that of its fellow jaw of the angle, but a space exists. The united mouth frames are in contact externally with the first plates of the arm, and the vacant space between the frames of the jaws which coalesce within, is in relation with the cavity of the body which is outside the stomach—the generative cavity. The arm, then, springs as it were from the union of the outer parts of the

* Edward Forbes described the nerves of the Daisy Brittle Star, and noticed that there were no ganglionic enlargements, and he stated that each arm was supplied with two pairs of nerves from two sets of the main [illegible] —*British Star-fishes*, c. viii. 41.

jaws of two angles, or, in other and more correct words, the jaws are modified arm-endings, being composed of two arm joints, the inner one of which is bent down so as to be lower than the other.* If a side look can be got at a jaw angle (fig. 9), by cutting an Ophiuran across the body along the line of one of the arms, the jaw will be seen to be deep and to extend very visibly from above downwards. On the side, are two holes and two scales or scale-like spines, an upper and lower, and they are for the upper and lower mouth tentacles. These long, slender, fleshy, hollow bodies come out through the holes, and their tubular cavities are continuous with the circular water canal, or rather with an offshoot which makes its way to the arm, passing obliquely downwards and outwards to reach a groove, which, in the natural position of the Ophiuran, is just above the lower arm plates in the body of the arm and in the median line. As each of the five main branches passes off from the circular water canal, close to the rim of the stomach membrane, to reach its special arm, the side branches for the first two tentacles are given off, one after the other. This dipping downwards and outwards of the main branches, is accompanied by a similar distribution of nerve, and the nerve cords cling to the water systems, being enveloped in fibrous tissue in a common sheath. Every tentacle in the arm has its offshoot from the radial vessel, and it is short and ends in a *cul de sac*, the tentacle not being open at its tip. There is no mechanism to produce a sucker, and those organs are wanting; consequently there are no extra contractile sacs associated with the tentacles and in connection with the water system, as is the case in the Star-fish. The radial water canal passes, then, along each arm, associated with nerves, and at each joint a water tube and nerve are given off, on either side, to the tentacles. Probably the tentacles have something to do with respiration. The arms, as already noticed, consist of a series of four plates, united more or less closely by skin, and there is an opening at each joint or cale on either side inferiorly and between the side arm plates and the lower arm plate. The member thus enclosed in armour in many genera, and having much visible skin between the plates in others, has an internal skeleton, the explanation of whose ancestry defies the most imaginative biologist. It is a structure *per se* in the Echinodermata, and is as elaborate a piece of mechanism as can well be imagined. The use of it is evident enough, and there is some correlative relation between its elaboration and that of the side arm plates. That is to say, in those genera where the

* There is a capital diagram of this by Theodore Lyman, in "Ophiuridæ," &c.—Bulletin of the Museum of Comparative Zoology at Harvard College, Cambridge, Mass. Vol. iii. No. 10.

side arm plates do not encroach, over-much, upon the upper and lower surfaces of the arms, the internal skeleton is well developed; but where the side arm plates form a large portion of the arm, then the elements of the structure inside are [illegible] represented. They are not wanted, for a dense squa[illegible] covering capable of but slight movement exists. But when the ordinary mobility of the arm from side to side and a little of an extraordinary kind from the horizontal downwards are possible, and the outside plates are not too close or rigid, then the long line of ossicles inside each arm is perfect. The resemblance of the inner skeleton of the arm to the vertebræ of the higher animals is, of course, only superficial, but nevertheless some of the methods by which vertebræ are joined together in the Ophidia and mammalia are foreshadowed in it. On breaking the arm of an Ophiuran across, near the body where one joint is connected to another, that is to say, between two consecutive lower or upper arm plates, the central part is seen to be filled up with a rather complicated structure or ossicle, which presents two surfaces. One, seen on the broken face of the arm left attached to the body, is the external, and another, on the separated piece, is the internal, and they fit one on to the other and are joined during life by muscles. The contour of the ossicle of each joint, conforms to the outline of the arm, in transverse section, and its length corresponds to that of the outer plates. The ossicle adheres by the agency of fibrous tissue and muscle to the upper arm plate above, and to the other plates in their proper positions: but it has a decided groove on its under surface in the median line, and this is turned into a canal by the contact with the upper surface of the lower arm plate. A smaller groove is noticed above, and is beneath the lower surface of the upper arm plate. These two grooves are in a vertical line which would separate the ossicle into halves, and the lower one contains the extension of the water system and nerve from within the body. The surface of each ossicle has certain knobs and pegs, cavities for their reception, and broad spaces for muscular attachments. Thus the inner surface has rather above the middle, yet centrally, a broad projecting knob, and near the lower edge two smaller knobs, one on each side of the median line, in which and between them there is a depression or socket. On the external side of the ossicle three cavities exist, which correspond with the knobs, and they fit them, and there is also a peg which fits into the socket in the other ossicle. Rotation or twisting of the arm is thus prevented, and also too much up and down movement, whilst some latitude exists for side to side motion. Considerable surfaces exist on both faces, into which muscles are fixed, and there are muscular fibres on the outside of the ossicle attaching it to its fellows before and behind.

On looking at the top of an ossicle, underneath the upper arm [illegible] e, the small groove is seen, and on either side of it a [illegible] dish angular flap on which the upper arm plate rests and [illegible] ich is the homologue of the mouth or jaw frame. Inter[illegible]lly there is a concavity for the reception of the peg of the next ossicle within, and externally is seen the peg itself. The lower surface of an ossicle shows the large median groove for the water tube and nerve, and there are two marks, one on either side, where the tentacles rest as they pass outwards to the surface, and also the peg and socket in their relative positions fore and aft.

There is an offshoot of the water tube and nerve to each tentacle, and there are nervous filaments crossing the muscles which are on either side of the median pegs and holes. The decalcification of an arm in a small specimen will render the vessel and nerve visible, and it appears that they are enclosed in rather thin fibrous tissue, the nerves being numerous, excessively delicate, with numerous nuclei, and they surround the water tube. (Fig. 8 *x*, *y*, *z*.) This is cylindrical, but it swells at the joints of the arm plates where the branches are given off, and its walls are thick, transparent, and sparely nucleated. (Fig. 8 *z*.) The muscular fibres are unstriped, and most are simple; but many are compound and branch and unite, forming a plexus. Many extremely delicate and narrow fibrils wander about the muscular fibres, and probably they are nerves. Moreover the impression remains on the eye, that there is an opening at the joint between the meshes of the muscles and the water tube, as if the fluid could pass into the tissue.

In the instances where the plates of the arms are not well developed, as in the genus *Ophiothela*, whose species cling to Isidinæ and even to other Ophiurans, and in which skin and grains of carbonate of lime almost replace the plates, the ossicles are still developed. The arms are of great importance, and they form, by a morphological metamorphosis, the jaws and teeth and support the nervous and vascular systems. A few words must suffice to notice the spines of the arms. They are situated on the side arm plates, and on the front, free outer margin: they are close to the side and point along the arm in Sand Stars, which have but slight lateral movement in the arms; and they project more or less at right angles from the arm in the other Ophiurans. Those bristly-looking arms, characteristic of Brittle Stars, are competent to move and wriggle sideways to any extent. Exquisitely beautiful are some of these spines, and especially when they are of a glassy transparency. They frequently move on a rough ball and socket-joint, and are often numerous and even crowded, or are placed in one row. Besides these accessories to the side arm plates, there

are scales and spinules on them close to the tentacular openings. These are small and broad as a rule, single or multiple, and occasionally, some are on the lower arm plate. Their duty is to protect the base of the tentacles. A third kind of spine is noticed in the small group of Ophiurans which clasp by bending their arms downwards. These spines are really hooklets, with two or more sharp recurved brilliantly transparent teeth, and the side arm plates resemble flaps stretching out from the arms more than anything else. Similar, but less elaborately ornamented, hooks are found in many Brittle Stars, and usually the spine next to the tentacle is thus formed. Some Sand Stars, such as *Ophioglypha*, have a hooklet near the end of the arm instead of one of the spines, and Mr. Percy Sladen has found them in our North Sea forms.

Almost every naturalist has read Edward Forbes's account of the spines of the Thread-rayed Brittle Star, which lives in soft slimy mud. Its third spine on the side of the joint is the largest, and instead of tapering to a point like the others, is furnished at its extremity with two transverse-curved spiny processes, giving it exactly the form of a pickaxe. Forbes considered that the arrangement would be useful in working about in the mud.

The arms are readily cast off, in different places, in many species of Ophiurans, and often the disc alone may remain, the extremities wriggling for a while and dying, and the disc hoping to grow its arms again in time. Reparation is almost as certain as the mutilation. The Brittle Stars are extremely apt to break, and hence their very appropriate name; but it appears that in perfectly comfortable circumstances one of them should and can carry its arms out of the battle-field of life safe and sound. Foul water, fright, what might be called in higher animals hysteria, and accident, produce breaking in bits, or the whole arm is cast, and the only way in which the process can occur, is by dislocating the system of pegs and sockets of the ossicles. Too great bending of the arm upwards, brings the lower peg out of its socket, and then there is a stress on the large upper one. The least excess of action of one set of side muscles over the other, will carry the ossicle out of its axial position, rupture the water system and nerves, and then the next motion of the joints nearer the body, will separate the structures.

It is necessary, in conclusion, to notice the reproductive organs whose position is in the body around the stomach bag, and external to and above the water tube and nerve ring. On turning the Ophiuran on to its proper upper part, and then examining the body close to the arms within the disc, slits will be seen parallel with them; in some genera there is one on each side of [illegible] on the body, and in others there are two, one

'ore the other. These have often granulations or spinules on ·ir edges, and may be short or long. (Fig. 10 *g*, 2, 6.) A ·dle placed in one goes into the body, and if pushed on, will ne out at the top through one of the ten large plates which placed there close to the upper edge of the arm and on one e. These are the radial shields. (Fig. 1 *a*.) If the needle ɔushed inwards towards the mouth it will be stopped beneath mouth shield on the under surface by the jaws as they pass ɣards and sidewards from the arms: and if the instrument pushed in the opposite direction it will be stopped by the ide of the edge of the disc. In fact, there is a space which is ıs situated outside the stomach and jaw apparatus and beneath shields, and it may be subdivided into ten, two in each erbrachial space, or there may be a greater or less general ·ity extending from one arm space to another over the arm, ming a marsupium or pouch. In the spring time, the ces are crammed and the disc is swollen with ova, red in ɔur, and there may be masses of white, which are sperma- oa. They are in and amongst much connective tissue form- a set of bags. Water passes readily through the generative s into the chambers, and at the proper time the ova burst th to pursue a very remarkable metamorphosis. Years since, ng and perfect tiny Ophiuroids were found in the pouch of parent, and there is no doubt that then the ova are hatched hin, and that the metamorphosis is skipped.

DESCRIPTION OF PLATE VII.

ig. 1. The upper surface of a Sand Star, *Ophioglypha Sarsii*. *a* = A radial shield.

IG. 2. The under surface of the same Ophiuran. *b* = a mouth shield. Generative slits by the side of the arms.

IG. 3. The side of the arm showing (*u*) upper arm plates, and (*m*) side arm plates, carrying spines and minute tentacle scales.

IG. 4. View from below (in the proper position of the animal) of a jaw angle in a species of Brittle Star, *Ophiothrix*. *d* = a jaw; *c* = a side mouth shield; *b* = mouth shield; *t p* = tooth papillæ and at their end some teeth. The oval with the tooth papillæ is aslant, and on a higher level in the natural position than the jaws *d*. A tentacle (*q*), the lowest of the angle, is seen on each side close to the side arm plates.

IG. 5. View from above of ends of teeth and jaws; the curved line marks the attachment of the membrane of the stomach, and external to it would be the position of the nerve cord. *e* = teeth; *e p* = tooth or jaw plate; *d* = jaws; *s* = stomach line. The dotted lines note the line between the jaws.

FIG. 6. The under surface of a Brittle Star. *Ophiothrix.*

FIG. 7. The side view of two jaws with their teeth, the space between leads to the stomach above and mouth below, in a small Sand Star. *e* = teeth; *d* = jaw.

FIG. 8. Water canal and nerves of arm, removed from the fibrous canal or sheath. *x* = a plexus of nerve fibres on the water tube; *y* = water tube; *z* = a nerve on a portion of the water tube. Magnified with a quarter-inch object glass.

FIG. 9. An oblique view of the jaws and other plates of the mouth after Lyman; *d* = jaw; *c* = side mouth shields; *b* = mouth shield; *m p* = mouth papillæ; *e* = teeth; *e p* = jaw plate. The upper and lower tentacles of the angle are indicated by dotted lines, and their scales are at their exit from the sides of the jaw.

FIG. 10. The relative position of the mouth shield and the generative slit; *g* = slit; *c* = side mouth shield; *b* = mouth shield.

COAL AND COLLIERY EXPLOSIONS.

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FRINGING the coasts of a large portion of Britain are lines of raised beaches, submerged forest beds, and inland tracts of peat, resting on marine and estuarine deposits, indicating a succession of elevations and subsidences, characterized by periods of vegetable growth, alternating with still longer epochs of deposition. Nowhere, perhaps, can this sequence be studied to better advantage than in the lowlands lying between the Mersey and the Ribble, and nowhere could be found better examples of the probable method of formation of the various measures and coal seams of the adjacent West Lancashire coal field. Careful examination of all the thicker coal seams show them to consist of distinctly stratified vegetable matter separated into groups by earthy partings, which vary in thickness, even in different parts of the same colliery, and which, when followed to a considerable distance, are often found to not only expand, but to be associated with other sedimentary material, so that the two layers that form one coal seam at the first point, become separated into two distinct seams in the more distant area.

An exact parallel to this may be found in most of the Lancashire mosses, thin planes of grey clay traversing the centre of the moss, gradually expanding towards tracts where the water was deeper and currents brought in foreign material, until the basin-shaped hollow was filled up, and the growth of peat went on.

All who have studied geological sections, especially in their relation to the structure lines of scenery, will have noticed the tendency valleys have to occur along lines of anticlinal axes; while the synclinals, or inward dips, constitute planes of strength which are noticeable in nearly all our hills of all geological ages, and especially in those which have longest withstood the wearing and degrading action of later denudation. The coal fields are, however, a noteworthy exception to this, for though

seldom rising into hills, they are almost invariably found in a basin, which can be proved in many cases to be a *synclinal* not merely of subsequent movement, but of contemporaneous deposition. In other words, the vertical distance between two given coal seams or other horizons is greater in the centre than on the edges of the coal basin; the thick coal seams of the circumference of the area have divided finger-like towards the centre, where the land was subsiding at a quicker rate, and the intervening space has been filled in by sedimentary material, deposition keeping pace with the rate of subsidence, so that the uppermost coal seam covering the whole is contemporaneous over the whole area. The Staffordshire thick coal, splitting into so many seams, is perhaps the best example of this. In the Newcastle field there is a thinning and splitting towards the centre of the coals, and thickening of the sediment. This is also the case in Lancashire, the measures between the Arley and Ince Yard coals thickening towards the centre of the basin 66 feet per mile for each mile traversed, or from 1,500 to more than 2,300 feet. And here the remarkable fact works out that at the time of the formation of the Arley seam the rate of subsidence was the same over the whole field; but a little later in time an axis of greater subsidence came into being, which gradually travelled to the north-east during the deposition of the whole of the middle coal measures, until it reached the district around Wigan—the area where the celebrated Wigan cannel is of greatest purity and thickness. Here vegetable matter would reach its most complete condition of maceration, and here the cannel-coal vegetable matter in the most extreme state of comminution is thickest. Associated with the cannel are the scales of large fishes, which, salmon-like, swam through the water from the more open sea. With the cannel and at various other horizons in the coal-field are thick seams of *Anthracosia* shells, near to our freshwater mussel. Whether they represent it or the estuarine condition indicated by the *Scrobiculariæ*, which so constantly occur in the grey clays intercalated with the Lancashire mosses, is still a moot point with naturalists.

The character of the trees found at the base of the Lancashire mosses varies with the nature of the underlying soil. Generally the roots penetrate the grey estuarine or fresh-water clay beneath, resembling much in appearance and chemical composition the underclay of the coal measures, containing the stigmaria-roots of sigillarian tree trunks, found broken and scattered in the coal and shale above, just as the trees found in the mosses have been broken off at a certain distance above the ground.

Through obstructed drainage, water has accumulated around

ıe trunks in both cases, leaves have fallen around the trunks, og and morass have formed, cutting off all supply of oxygen om the roots, the gas which forms so essential a constituent of ıe sap, and without which the tree cannot live: the decomposi- on going on, the fallen vegetable material must have robbed ıe soil of its oxygen until all the iron in it was reduced to rotoxide, and an effectual barrier to the entrance of all fresh xygen produced: no less than 4·73 per cent. of protoxide of iron eing found in fireclays by Dr. Frankland. After the death of ıe trees, the trunks appear to have been snapped off by preva- ınt winds along the line of junction of water and air, and both ı the coal measures and in the mosses there is generally a eterminate direction in the lie of the trunks. The growth f peaty material gradually covered up the trunks, and subsidence lacing the surface beneath the water level, the whole became overed up with sand and mud, borne by currents which occa- onally have completely cut out the coal seams, since filled in ith sandy material forming the "rock faults" of the miner.

Through subsequent pressure the coal has obtained an elabo- ıte system of jointing, which maintains an average general irection over extensive districts, but differs in different coal- elds, doubtless running parallel to the main lines of move- ıent which traverse the district, some of which have again rought the coal-field to the surface, or to comparatively short istances beneath the cover of underlying rocks.

Bischoff, Graham, and Playfair have shown that the gases volved by coal contain from 66 to 94 per cent. of light carbu- etted hydrogen, and that nitrogen is always present, sometimes mounting to from 14 to 21 per cent. of the entire volume, which an only be explained by "supposing that air has permeated he fissures of the coal and, acting upon it, has been robbed of s oxygen, partly by union with hydrogen, partly with carbon."

The process of decomposition of the coal is still going on nder conditions of considerable pressure and tolerably high emperature; the elimination of carburetted hydrogen, carbonic cid, and water, forming the much-dreaded "fire damp" of the ollier, is the result. It will be remembered that the composi- ion of our atmosphere in a state of purity is, in 1,000 parts, 88 nitrogen, 197 oxygen, 14 moisture, and 1 carbonic acid, ombined mechanically, and that an adult vitiates a cubic foot f air a minute. Then the capacity of the air for holding ıoisture increases with its temperature, holding 2 grains per ubic foot at 30° F. and 7 grains at 70°.

The ventilation of a colliery has not only to provide a fresh ıpply of air to replace that vitiated by the colliers, each of hom exhales 6·3 gallons of carbonic acid hourly, but has to be f sufficient strength to sweep away all inflammable gases issui

from the coal. This is effected by having two shafts, and by placing at one of them, which forms the upcast, either one or more furnaces in the different coal seams worked, or a revolving fan at the top of the shaft, which extracts the air in the workings.

Forty years ago no mechanical means were in use for measuring the velocity of currents of air passing through a mine, the rate being then ascertained by carrying a lighted candle exactly at the same rate as the current, so as not to deflect the flame, which method is accurate up to velocities of 400 feet per minute, but is not applicable to the principal splits of large collieries of the present day, in which the speed of the current would require a person to run. Another method that is still used for measuring its velocity is watching the time gunpowder smoke takes to travel over a given measured distance, of which the sectional area is known.

The first anemometer was invented by Mr. Thomas Elliott (a brother to the present baronet, Sir George), in 1835, and was worked by "the air acting on four wands, similar to a windmill, which met so strongly with the approval of the coal-owners" that they presented him with ten guineas; but they did not adopt it in one of their mines.

Anemometers that have since been constructed belong to three classes :—

(*a.*) Vanes revolving by impingement of the current of air, registering rate by a pointer, as Combe's, 1837; Biram's, 1842; Whewel's, Osler's, and Robinson's.

(*b.*) Instruments not revolving, but affected by the force or impulse of the wind, as Dr. Lind's, Henaut's, Bougier's, and Dickenson's. The latter consists of a light, counterpoised, flat fan plate, usually made of talc, being on two fine bearings. The plate moves up an arc, graduated in feet, which gives the velocity per minute, which, multiplied by the area, gives the cubic quantity.

(*c.*) Those of a more complete character, as Leslie's, in which the velocity is deduced from differences of temperature.

An ingenious application of the telephone, to test the state of the ventilation of a mine without a descent being made, was tried last year on the Wigan and Whiston Collieries, by Mr. Hall, H.M. Inspector of Mines, in the presence of Sir William Thompson. One of Biram's anemometers, generally used in collieries to detect the velocity of the air, was attached to a telephone, in which a small thin iron box was substituted for the ordinary diaphragm, which vibrated at every tenth revolution of the anemometer; this was taken down the shaft and main intake and connected with a telephone in the office on the

by 600 yards of ordinary coated electric wire. The

vibration was distinctly heard, giving 2½ beats a minute, or 280 revolutions, which, multiplied by the area of the roadway, gave the quantity of air passing.

Fire-damp mixed with air in the proportion of 1 to 4 produces drowsiness when inhaled, and when increased to 2 to 1, suffocation follows. When it only forms $\frac{1}{14}$ to $\frac{1}{13}$ of the whole volume, the flame of the Davy lamp increases and gradually enlarges, and becomes surrounded by a pale blue halo, or "cap," as it is called by the colliers. When $\frac{1}{5}$ or $\frac{1}{4}$ of the volume is fire-damp, the mixture is highly explosive; and with $\frac{1}{3}$ a lamp will not burn for want of oxygen.

The Davy is used as a sort of gauge to determine the presence and quantity by the colliers, and especially by the "fireman," whose duty it is to examine the colliery before the men enter, for gas, as well as to fire their shots, during the day. The lamp is held close to the roof, and gas is indicated by the blue cap; but the whiter the flame, the quicker it fires; if the flame elongates, or flutters, it is gently drawn down so as not to be allowed to fire. If the lamp fills with flame, and continues burning, the collier pulls down the wick with the "pricker," and endeavours to extinguish it by plunging it into water, covering it with a woollen jacket, or dust and *débris*. If it cannot be extinguished, an explosion results.

A Davy lamp is constructed of parallel iron wires, twenty-eight crossing each other in a square inch, leaving 784 apertures to each square inch of surface: when the gauze is new, or covered with oil, and raised to a red heat, it gives off inflammable vapour, which will ignite at that temperature, but this is only the case when the heat is applied from the outside, which is almost impossible in practice.*

Professor G. Forbes has just described, at the British Association Meeting at Dublin, an instrument for determining the quantity of fire-damp in mines. It consists of a metal tube resonator, one inch diameter, and 15 inches long, in which a

* Other experiments made by the North of England Institute of Mining Engineers show that "an inflammable mixture of pit gas and air, moving at the rate of 8 feet per second, will explode against a stationary Davy lamp without a shield," and at 12 feet with a shield, at 9 feet with a Stephenson lamp, or with a Clanny lamp.

The comparative illuminating power of these safety lamps, using a wax candle, six to a pound, is as follows:—

	Average number of lamps required to equal a wax candle
Davy's lamp	8·00
Stephenson's lamp	18·50
Clanny's (glass)	4·25
Mueseler's (glass)	3·50

piston slides, and a tuning-fork of definite pitch attached to a block of wood, to which is fixed the tube. The tuning-fork is sounded, and the tube moved out, until the proper length is found, which is indicated by the resonator intensifying the sound of the fork. A light gas requires a longer resonator, and the density of the gas can be read off the scale, and two per cent. of fire-damp mixed with common air, it is said, can be detected.

The writer of this paper has recently, in letters to the *Times* and *Colliery Guardian*, suggested still another means of detecting the presence and volume of fire-damp. Taking advantage of the well-known and, to the miner, disagreeable whistling or blowing of gas issuing from the pores of the coal, he has suggested that a telephone (or microphone) be placed against steady blowers of gas, and that these receivers be connected with deliverers in the colliery office, which might be made to speak to a phonograph, automatically worked by clockwork, so that a continuous record of the quantity of gas evolved from these given test points might be kept and studied above ground.

When it is remembered that the weight of the atmosphere balancing 30 inches of mercury is 2120·25 lbs. on each square foot of surface, and that a fall of one inch in the barometer indicates that the air resting on a square foot is 70·68 lbs. lighter, it will be readily understood how a sudden fall of the barometer may indicate a relief of the pressure, which has prevented the inflammable gases in the coal from emerging, and which, removed, allows them to pour into the mine.

The relation of changes of atmospheric conditions to colliery explosions have been carefully studied by Messrs. Scott (Meteorological Office) and Galloway (Inspector of Mines), with the result that 48 per cent. of the accidents might be attributed to changes of barometric pressure, the explosions generally taking place during the first fall after a long calm, and seldom until two or three days after the minimum has been reached. 23 per cent. were attributed by them to the temperature of the atmosphere, the first hot days of spring being especially marked by accidents. When the outside temperature rises, so as to equal that underground, all natural ventilation ceases, and if the mechanical means provided have not a wide margin, an explosion results.

A high surface temperature, by reducing the quantity of air passing through the workings, allows the accumulation of gas on sensitive points; while a very low surface temperature, by drying the coal dust in the mine, tends to make a mixture which is an exceedingly explosive vehicle, even when only one-seventh of the quantity of fire-damp is present, which is ordinarily explosive with air. That this is often a cause of accident, there

can be little doubt, and it becomes an important matter for consideration, whether a system of watering dry pits ought not to be adopted. On the other hand, many explosions take place in *damp* pits, as the Queen Pit, at Wigan.

Few accidents probably occur from the use of gunpowder properly applied, no flame resulting from a shot which takes effect; but when the tamping is defective, from bad workmanship, or from a very hard rock, the shot is blown out like the bullet from a gun, fire-damp dislodged by the vibration or fall of roof may be directly ignited by the flame of powder gas issuing from the hole, or it may be driven by the sound wave through the meshes of a distant safety lamp: to the latter cause, which has been carefully investigated by Mr. Galloway, the firing of the larger number of explosions is doubtless due. But the Haydock accident proves that if ever the use of powder were discontinued altogether, this class of accident would still continue; for here the gas was ignited by the men simply by running against the stream of gas-laden air. Many days after the explosion, Evans and Clare's place, six or seven yards from the Downall Green Fault, still received so large an amount of gas that, on turning the ventilation away from it, it filled with explosive gas in four minutes, or 1,250 cubic feet of gas a minute, and lamps fired on the spot, when 13,600 feet of air played on it.

In the opinion of the Government Inspector, this explosion was not due to the "blower" of gas, but to fire-damp issuing from the adjoining old workings, the edge of which was swept by the ventilation, and which it visited first, travelling in all 300 yards from the bottom of the downcast shaft to the bottom of the upcast, supplying 200 men, and 11 horses, the amount being 28,000 feet; but this quantity is equivalent to a much larger amount in a colliery in which gunpowder is used, which was not the case in the Wood Pit.

By the Coal Mines Act, the inspection of every mine in which gas has been seen within twelve months has to be carried out every twenty-four hours, before the men enter, when one shift are working, and every twelve hours when there are two. All workmen are to be withdrawn when noxious gases prevail, and the place inspected. No lights but locked safety lamps are to be used in places where gas is likely to accumulate. Gunpowder is not allowed to come into a mine in more than 4-pound canisters, nor more than one canister to be in one place at a time. Iron or steel is not allowed to be used for charging holes for blasting.

When gas has been present during the past three months, cartridges are alone allowed to be taken into the mine, and may only be fixed by the proper official, and if a blue cap appear on

the flame of the safety lamp, cartridges may only be used in stone drifts, shafts, and places where the return air does not go into any working places, or when no persons are in the mine.

By the special rules, if a shot misses fire the place may not be examined until the lapse of an hour; and if, notwithstanding adequate ventilation, the issue of gas from the strata is such as even to show to the lamp, not actually fire, no shot may be fired until the ordinary staff is withdrawn from the pit. Further than these rules—unless the use of powder and other explosive or inflammable substances be altogether prohibited—it appears impossible to go.

The 46th clause of the Mines Regulation Act, 1872, prohibiting the use of gunpowder in dangerous seams, has recently been supported in an arbitration, conducted by Messrs. Higson and Wood, restraining the East Hetton Coal Company from using powder in working the Harvey seam on the long wall principle.

In North Staffordshire and Shropshire, Mr. Wynne reports that the use of powder in blasting is the fruitful source of explosions of fire-damp; that it shakes the roof and renders it dangerous, and, used indiscriminately, tends to the production of small coal, and the subsequent breaking-up during railway carriage of the large.

In Yorkshire, Mr. Wardell reports that the Barnsley and Silkstone seams should be worked with the safety lamp and without powder.

In Durham, Mr. Bell reports that mechanical ventilation has completely demonstrated its superiority to the old furnace; and Mr. Wales reports that nearly all the large collieries in his district have large fans at work.

The use of gunpowder in working pillars ought to be discouraged, as gas lodges in cavities in the roof, which it is impossible for a "competent person" to examine, falls of the roof constantly occur, and block up the air ways. After a fatal accident of this nature in 1876 in the 7-feet coal at the Moss Pit Main, Wigan, the use of powder was replaced with good effect by wedges, invented by Messrs. Dingley and Ackers.

A fatal accident occurred in the same year, while taking out pillars at the Westminster Colliery near Wrexham, through fire-damp issuing from an old goaf, igniting at the *candles* used by the men! Naked lights are commonly used in a large number of collieries in North Wales; and the district also has the unenviable distinction, according to Mr. Hall, of the largest number of roof accidents of any in Great Britain. In Scotland, in the western district, half the accidents of 1876 were due to this

In some districts, timbering is done by the men; in
s in Durham, by the officials; but even there the

Inspector, Mr. Bell, reports that great carelessness is displayed by the men in neglecting to examine and prop their places in the absence of the deputy, or other officer; but that it has been elicited at inquests that the time allowed the collier is not sufficient for him to do his work and attend to his own safety.

In the opinion of Mr. Dickenson, the Senior Inspector of Mines under the Home Office, "*attention to safety has now been brought almost to an extreme point.* To carry it further would be impossible without making life miserable." Colliery accidents of all classes have been steadily decreasing during the last quarter of a century.

Though occasionally accidents may arise from ignorance or evasion of the law on the part of some of the staff, there can be little doubt that the large majority of explosions are due to several conditions happening at one moment, which, with our present appliances, no foresight exercised or discipline enforced on the part of the management, can possibly provide against. Just as some of the most terrible railway disasters occur to railway companies who spare no expense in providing the best rolling stock, the best steel rails, the latest signals, the most experienced staff, through an unfortunate combination of circumstances, so with the best managed mines, receiving a perfect and ample amount of ventilation, a sudden outburst of gas, from a fall in the barometer, rise in temperature, and some local unavoidable accident in the mine, which would be unimportant at any other time, brings about the fatal combination, and a catastrophe results.

No better example of this can be given than the explosion on Oct. 11, 1877, in the Wigan 9-feet coal at Pemberton, belonging to Messrs. Blundell, in which not only were 33 men killed by the accident, but my able and unfortunate friend Mr. Watkin, with two of his managers, was killed by the after-damp, in their heroic attempt to save life.

The pits are 640 yards deep, and are sunk to the Wigan seams, the King and Cannel coals, the Orrel coals, the lowest of which is the well-known Arley mine, the lowest but most valued of the Lancashire coal seams belonging to the Middle Coal Measures. The downcast or Queen Pit is 17 feet diameter, the upcast or King Pit 19 feet 4 inches at the top, and 18 feet at the bottom; the sides are lined with firebricks, and on each side are a pair of railway metals in which run the cages, six in number, and made of steel, with the steadiness and precision of an hotel lift. The two shafts are connected underground, and the ventilation effected by a Guibal fan, 46 feet in diameter, and 15 feet in width, driven by two engines, either of which is equal to the work on an emergency, no less than 225,0(cubic feet of air per minute being set in motion. The air en

the fan through a culvert, at the top of which there is a large escape chimney with 4 large doors to allow the air to escape, should there be a blast, without injury to the fan.

The accident was doubtless due to a blown-out shot, the effects of which have been known to travel 300 yards, and to blow down a door 80 yards distant. And though a fireman may carefully try for gas at the firing point, and it may not show in his lamp, when only one or two degrees below firing point, the dislodgment by the shot may add that small additional amount of gas requisite to make it explosive. In cases of this sort, it appears well-nigh impossible to guard against explosion so long as powder is used, in any inflammable coals. At Low Hall in Lancashire, the danger is reduced to a minimum by firing all the shots at night, which is adopted by Messrs. Cross Tetly's in the Wigan 9-feet; at Park Lane this coal is worked without powder; at the Queen Pit, Pemberton, and at the Moss Pit it is not worked at all since the accidents at the respective places.*

Gas is steadily and continually being given off by fiery coals, and the more perfect the ventilation, and the less it be interfered with, the more easily is it swept away; at night when the ordinary operations are not going on, and doors being opened and shut, tubs ascending and descending, the ventilation is much more undisturbed, and the danger resulting from firing shots much reduced. At night also few lamps are in the pit, and the danger of the flame being forced through the lamp by the sound wave is much reduced. Great danger results from the employment of inexperienced persons, attracted, by the higher wages to be earned underground, from the plough and the spade, who are utterly ignorant of the use of the Davy lamp, and each one of whom is a source of danger to his fellow workmen.

The Blantyre colliery is 15 miles from Glasgow, and consists of three shafts, No. 2 being rectangular 16 feet by 8, and 130 fathoms deep; No. 3, 24 feet by 8, and 155 fathoms deep, and an upcast circular shaft 10 feet diameter, and 127 fathoms in depth. Though the mine has only been opened four or five years, 24 statute acres have been opened out, by cutting levels up the dip of the coal, or down the dip, as suited the convenience of working best, and leaving pillars 22 yards square, which system is called in Scotland "stoop and room," the stoops being the pillars. It will readily be understood that the difficulties of properly ventilating such miles of passage must be very great if not insuperable. Mr. Pickard, the agent of the Miners' National Associa-

* Five coal-seams were ventilated from these pits, the Wigan 4-feet mine taking 48,700 cubic feet of air; the 9-feet, 15,200; the King coal and cannel, 50,580; the Orrel 4-feet, 34,360; the Orrel 5-feet at Arley Main, 43,630.

tion, who assisted in the recovery of the dead after the explosion, reports that out of the 26,000 feet of air supplied to the pit, 16,000 travelled in the south part of the mine, and by the time it had reached its destination had probably lost not less than 6,000 to 8,000 feet, having to supply air through 756 yards of wood brattice and 17 stoppings.

The men who worked in the colliery at the time of the explosion used naked oil lamps fixed in their caps, in a mine in which seven days after the occurrence which destroyed more than 200 men, no less than 60 yards of level was filled with gas. Shots had been fired by the men, in the firemen's absence, and the traces removed with clay and sandpaper, and only a dozen Davy lamps were on the premises.

The explosion at Haydock on June 7 of this year took place in the Wood Pit, which has two shafts, 78 yards apart and 243 yards deep, and both are on the north side of the Red Rock Fault. The Higher Florida coal at 105 yards, and the Lower Florida at 118, are worked out. At 217 yards is the Ravenhead Higher Delf partially worked, from which a tunnel was driven through the fault, to the Higher Florida, which is thrown down 170 yards.

The workings of the Higher Florida Mine south are bounded on two sides by faults, which are known in the district as the Downall Green, north-south fault, and the Red Rock, east-west fault, which meet in the highest point in the mine, near which was the spot where Evans and Clare worked, the men in whose place the gas was.

Gas also appears to have been evolved from the old workings near the Downall Green fault.

The ventilation came through the tunnel above mentioned, and after passing through the workings made its way through a special air course, to the North Ravenhead Main Delf workings, and thence back again into the upcast shaft, the whole length of the air being 400 or 500 yards. Two furnaces in the upcast shaft at different heights provide motive power. No fans or steam jets were used till after the accident.

On the south side of the fault, the High Florida is 279 yards from the surface, 4 feet 6 inches thick, and a soft and freely worked coal not requiring blasting; no powder was used in the seam at all, and the Davy lamps belonged to the firm, and were kept riveted, and metal-sealed with their initials.

To expect that an ordinary gang of pitmen shall have a knowledge of the physical laws on which their safety depends, is for the present an impossibility, for large numbers of these men can neither read nor write; but there ought to be no difficulty in teaching them the provisions of the Act of Parliamen which they as well as the management are by law obliged

obey,* and it would probably be found that accidents would considerably decrease if no man was allowed down a pit, until he could pass a *vivâ voce* examination in the provisions of the Act, and the management of the Davy lamp. Instruction of this sort should be given by the management at the surface, and followed up under ground; and the new men should be taught the indications by which old colliers can detect the presence of gas, by its action on their eyes and nostrils before it shows in the lamp.

How entirely the collier trusts his safety to others, is shown by the 30th general rule, allowing him to appoint two of his number to inspect every part of the mine once a month, being practically a dead letter, with the one exception, that owners provide annually a report book for this purpose, which is never used.

Apart from personal anxiety for the safety of his men, no one can doubt that every coal owner and manager is only too willing to carry out every improvement, and induce every man to guard against explosions, when he realizes the terrible struggle and almost superhuman efforts that are necessary to clean and renovate a colliery that has been wrecked and destroyed by such an accident, entailing a cost, which with the small margin of profit

* The following table, drawn up by Mr. Dickenson, shows the good results which have followed the inspection of mines—and that, notwithstanding the sad casualties in Great Britain in 1877, it was twice as favourable as the early years of inspection:—

	Total accidents	Persons employed	Employed to each accident	Deaths	Employed to each death
1851	698	216,217	310	984	219
10 years ending 1868 . .	7,739	2,460,322	318	10,018	245
10 years ending 1870 . .	8,228	3,102,405	388	10,626	300
1871	826	370,881	448	1,075	345
1872	894	418,088	468	1,060	374
1873	973	512,109	526	1,069	479
1874	895	538,829	602	1,058	510
1875	927	535,845	578	1,244	430
1876	839	514,532	613	933	551
1877	864	494,386	572	1,208	409

The deaths in 1877 being more in proportion than in 1876, it is of interest to examine to what they are due; and taking Mr. Dickenson's own district, North and East Lancashire, as a representative area, it is somewhat startling to find that, out of 9 fatal explosions of fire-damp causing 42 deaths, 6 of these accidents occurred in places where naked lights are used: in several of these accidents blown-out shots sucked out the gas in the coal.

now earned in the coal trade, means ruin to the small proprietor, and no interest on capital to the large.

That no further compulsory power can be added by legislation to the powers already existing, provided they were carried out, appears to be a fact; but unfortunately this, with the present staff of inspectors, is not possible, for though the senior officer tells us he travelled no less than 15,695 miles last year, and was occupied 318 days in the execution of his duties, the districts given to those gentlemen are so vast, that Mr. Hall, in his evidence on the Haydock Explosion, which occurred in his district, tells us, he cannot pay his routine visit to any colliery under an interval of six years.

ON THE RADIOLARIA AS AN ORDER OF THE PROTOZOA.

By Surgeon-Major G. C. WALLICH, M.D., &c.

Continued from page 281.

It is in the second order of the Rhizopods, namely, that which comprises the *Plagiacanthidæ*, *Acanthometræ*, *Thalassicollidæ*,* and *Dictyochidæ*, that the first trace of structural advance is made manifest by the presence of a distinct membranous or "capsular" covering to the nucleus. The more deeply tinted masses, of which mention was made just now in the *Foraminifera*, though not true nuclei, owe their denser appearance to the accumulation of the minute sarcodic granules, which are more or less uniformly diffused in the more limpid and colourless portion, whilst the creatures are in their natural state. But there is every reason for believing that these granules are of the same nature, and contribute to the reproductive process in nearly the same way as the granules contained within the membranous capsule, and those present in the sarcode mass exteriorly to it, of the superior Order. But in this case the evolution of a true *tissue* undoubtedly indicates physiological advance, and hence becomes a safe Ordinal distinction.

In those Rhizopods which are endowed with membranous capsules, it seems probable that nuclear granules and even sarcoblasts are able, by some means or other, to force a way through

* If Hertwig's observations on the *Collosphæridæ* and *Sphærozoidæ* are as accurate as they appear to have been carefully made, it is evident that the whole of these remarkable composite forms, of course including the single exceptional genus *Thalassicolla*, ought to be removed from amongst the Rhizopods and placed—at all events provisionally—with the *Heliozoa* (assuming that these multiply also by *zoospores*, furnished with flagella, whether single or double), as a distinct group between the Rhizopods and the *Gregarinidæ*; inasmuch as neither the difference of habitat, nor the mere difference in colour of the sarcoblasts of the two families can be held to be a [illegible] their being kept distinct.

the capsular wall into the peripheral stratum of sarcode. In *Sphærozoum* and other members of the *Thalassicollidæ*, the transit of these bodies from within the capsular chamber to the space between it and the perforated siliceous shell appears almost certain, although I am not aware that the occurrence of a sarcoblast actually in course of transit through the capsule has as yet been noticed. But although it would obviously be premature to deny that any permanent apertures exist in it simply because they defy our vision, I am strongly inclined to suspect that they do emerge, and that the orifices are immediately sealed up again, since no mere osmotic action could possibly account for the phenomena. But until the existence of permanent apertures, or the actual transit of the sarcoblasts, despite the absence of such, shall have been seen, the whole question must, of course, remain an open one.

But to return to the arguments based upon the *presence* of the capsule. It is admitted by the supporters of "multiple cell-formation amongst the *Radiolaria*" (I presume only amongst the composite forms), that reproduction may take place: firstly, "by spontaneous fission or giving off a single or a few capsules, these modes of increase having, however, not been actually observed, though it is certain that single capsules (however derived, whether from spores or from segmentation) do exist separately. The colonies may also be increased by juxtaposition, and the mass of an existing colony by the rapid fission of its component capsules, the process taking place centrifugally in the shelled and irregularly in the shelless (*sic*) forms. Secondly, with regard to the capsules themselves, it is certain that they may increase by spontaneous fission into two, three, or more secondary capsules, and that this process may repeat itself indefinitely. Thirdly, with regard to reproduction by spores,* it is certain that such a process occurs in *Acanthometra*, *Thalassicolla*, *Sphærozoum*, *Collosphæra*, and *Collozoum*, AND MOST PROBABLY IN ALL THE RADIOLARIANS. The spores are formed by the breaking up of the contents of the central capsule into small particles, which become directly transformed into spores, each spore containing a nucleus and *fat*-granules, and also a crystalline body, when such bodies are found within the capsules in which such spores arise. Each spore is provided with a *flagellum*, and it is doubtful whether more than one *flagellum* ever exists to one spore." (Memoir, p. 167.)

* It will be seen that here, as elsewhere, in Mr. Mivart's observations, the terms "zoospores" and "spores" are both employed in describing the reproductive process in the *Radiolaria*. This must necessarily lead to great confusion, even were it possible, which it is not, to admit spore-formation in a single family of the true Rhizopods.

After saying that the contents of the capsule may break up into variously shaped masses, of various sizes, and that these again subdivide into zoospores, we are told that "these different sets of masses give rise to two kinds of spores, one set producing *microspores*, the other *macrospores*, bodies having *different but as yet unknown* functions; but that beyond these different stages no observations have as yet gone, *the transition from the zoospore to the capsule remaining unknown*. The zoospores, however, have no enveloping membrane, and the young central *capsules* are in like case.* If the capsules proceed from the former, the *Radiolaria* so far resemble the *Heliozoa*; and if the processes observed by Müller, as existing in the young enclosed *Acanthometræ*, resembled the processes of such organisms as *Actinosphærium*, we should have another approximation between these two groups." (Memoir, p. 168.)

In submitting these lengthy extracts I feel, nevertheless, that no apology is demanded of me, inasmuch as it can only be by perusing them that the inherent and amazing unsoundness of the Radiolarian arrangement is to be adequately estimated. As already stated, it is impossible within my present limits to discuss in detail the various points connected with the reproduction of the composite group—the *Thalamophora* as they are now designated. We have seen how very freely such expressions as *spores*, *zoospores*, *microspores*, *macrospores*, *flagella*, *spontaneous fission* of the *contents* of the *capsule* into any number of secondary *capsules*, *fat-granules*, *livers*, *cilia*, *parasites*, *alveoli*, and "*young capsules which have* NO *enveloping membrane*," have been made use of in describing the characters said to distinguish "the group of the *lowest animal forms called Radiolaria*." I simply put it to those who are practically conversant with the Rhizopods as a whole to say whether any organism whatever described as possessing characters such as those referred to ought for a moment longer to be retained in any classification of these organisms. As for telling us that "IF the processes observed in the young *Acanthometræ* resembled the processes of such organisms as *Actinospherium*, this would be another reason for approximating the *Heliozoa* and *Acanthometræ*;" it would, I submit, be just as pertinent were we to say that IF the *Acanthometræ* or any other group or family whatever of the Rhizopods (with exception of the avowedly aberrant *Thalassicollidæ* and *Sphærozoidæ*), propagated by zoospores, microspores, macrospores, and so forth, there would be reason for approximating *them* to the *Heliozoa*. It is these "*ifs*" which, in an elaborately written essay, make all

* There surely is some "clerical error" here!

the difference between fact and mere guesswork, and are therefore singularly out of place.

But despite all drawbacks, in attempting to advance the *Composite Thalassicollidæ* into the front rank of the "Radiolaria," Mr. Mivart has rendered us a signal service by so directing attention to them that it has become absolutely indispensable that the Radiolarian classification should be revised, and the proper location for the *Thalassicollidæ* determined. Whilst this is being effected it would be well to ascertain whether the *Noctilucæ* might not with propriety be referred to the same group. It is true that nothing is as yet known of the reproductive process of these remarkable and common organisms. But, after all, knowing too little is better than knowing too much. Time and patience usually suffice for the discovery of missing links; but neither time nor patience is profitably expended in proving negatives.

As for the "streaming of granules" and the occurrence of *pseudo*-pseudopodia imbedded within the extra-capsular sarcode of some of the *Thalassicollidæ*, both phenomena are present also in *Noctiluca*. And, to say the least of it, inasmuch as not a single example is producible of *endogenously* projected and active pseudopodia occurring *within* the body substance of any true Rhizopod, we have in this distinction a character which furnishes the very antithesis of an "approximative" bond between the former organisms and the latter.

Mr. Mivart alludes to the discovery by Haeckel, since his "*Die Radiolarien*" appeared, of the remarkable "*Myxotrachia*," which Haeckel associates with his "*Polycyttaria*," or compound *Radiolaria*. Not having seen this creature, I can form no definite ideas as to its relations. But I do not hesitate to affirm that, if the figure given of it is accurately drawn, although it may be a Radiolarian in Sir Wyville Thomson's sense, it is unquestionably not a Rhizopod, and that nothing could more forcibly demonstrate the purely arbitrary character of this classification than the admission of so palpably distinct a form, even allowing the fullest scope to Mr. Mivart's reservation that it is "a curious and exceptional form."

Before passing on to the concluding section of this article, I may be permitted to say that it is highly gratifying to find from Mr. Mivart's memoir that "*Hertwig* has strongly insisted (as I did fifteen years ago) upon the greater importance of A *Nuclear Vesicle* as a classificatory character than any characters which can be derived from the skeleton"; (Memoir, p. 173), and that Mr. Mivart "quite agrees that it forms a most important distinction, which he therefore proposes to adopt provisionally, fully bearing in mind that it may hereafter be very widely, if not all but universally, present in the group," adding

that he "*would anyhow make its presence or absence a* PRIMARY *character*, and therefore follow Hertwig in separating from Haeckel's '*Collida*' those forms which have the nuclear vesicle, and uniting them with the other genera which posses that structure into a group *Vesiculata*." (Memoir, pp. 173, 174.)

After a prolonged effort to satisfy myself as to what Mr. Mivart may mean when using the term "*a nuclear vesicle*," declared by him to constitute a most important distinction, &c., I am constrained to admit that I have given up the task in despair. Of course it may be that this is another of the convertible terms he so frequently employs, and is identical with the "porous membrane called the capsule," of which we have heard so much, which would in that case explain why the term *nuclear vesicle* was so carefully eschewed in the first thirty-six pages of his Memoir, inasmuch as it would have been an avowal of the *non-existence* of the declared typical character in the most important, widely distributed both in the recent and fossil state, and most typical (according to the accepted estimate) of the Radiolarian families, the *Polycystina*, of which I have been the persistent advocate. But then Mr. Mivart would have had to cancel one of the most important of the structural characters which he ascribes to six out of the seven great "sections" into which he now condenses the fifteen groups of Haeckel, and which he embodies always in the three words "No nuclear vesicle."

If, however, he employs the term to signify the presence of a *vesicular nucleolus*, within the true nucleus of such forms as the *Acanthometræ*, &c., he certainly appears to me to be assuming the presence of a structure in the Rhizopods, which does not, under any circumstances, enter into any portion of their organization.

From one short passage in Mr. Mivart's Memoir, this would however, seem to be his meaning. For, after referring (at p. 141) to the intra-capsular sarcode of *Thalassicolla*, *Thalassolampe*, and *Physematium*, which genera alone contain "Alveoli," he goes on to say that it also "constantly contains one or both of two sets of structures, which structures, according to Hertwig, bear to the whole capsule the relation of many *simple nuclei or of a single complex nucleus to a cell*;" and further, (p. 142,) that "the complex nucleus is a *small vesicle* the *Binnenbläschen* or *vesicula intima* of authors, formed of *porous* membrane similar to, but more delicate than the capsule itself." But even here a new element of confusion is introduced by the statement (at p. 162) that "Hertwig considers the capsule of *Collozoum* to be a multinucleate cell or *syncytium* ... es with Schneider in thinking *that it answers to the sarcode of the Foraminifer which lies within*

ell. He considers, therefore, that 'IT IS NOT AN ORGAN,' and ertainly not 'A GENERATIVE ORGAN!'"

I shall now proceed to bring these lengthy, though I trust ot altogether fruitless observations of mine to a close, by ketching as a supplement to my arrangement of the Rhizopods enerally, the classification and characters by means of which he principal subdivisions of the POLYCYSTINA, and every indiidual comprised within them, may, with a little care, be recogized and identified at any stage of their history, whether in heir recent or their fossil condition. (See pp. 374, 375.)

Order I. HERPNEMATA.—The primary and secondary chaacters of this order are as follows:—No definite nucleus. No ontractile vesicle. Sarcode without any permanent differentiaion into endosarc and ectosarc, but consisting of purely homogeneous, almost colourless, glairy basal SARCODE, within which granular particles, representing "*formed material*," of more consolidated texture than the basal sarcode, and of which the *arcoblasts* or yellow reproductive bodies, constituting in the *Herpnemata*, the sole representatives of the *nucleus* which is resent in the two higher orders, are mainly built up. Pseudoodia numerous, more or less irregular, and forming frequent nastomoses, and exhibiting when projected the characteristic henomena of pseudo-cyclosis. Both in the *Foraminifera* and *olycystina*, when in an active living condition, the exterior of he shells is invariably enveloped by a delicate film of the basal rcode. Shell or test, in the *Foraminifera*, either calcareous nd deposited in a crystalline state; or having a calcareous asis into which are impacted mineral particles selected from ithout by the animal. In the *Polycystina*, the mineral porion, which may rather be regarded as an internal framework or keleton than a true shell, is invariably siliceous, and throughout rmed into one continuous piece. (See Explanation of Plate VI., igs. 1, 2, 3 & 5.)

Order II. PROTODERMATA.—Definite nucleus present; nuclear nass presenting a nucleolus, and enveloped in *a distinct and irm membranous capsule.* Sarcode somewhat more differenated in appearance, but only in so far as the granular particles re, generally speaking, more closely confined to the central egion. Pseudopodia never so numerous as in the *Herpnemata*; nore rigid and tapering, and only rarely sending off branches rom one to the other. Reproduction by sarcoblasts;* which re to be seen in the general mass of the body-substance, and, ccasionally, within the nuclear capsule. These are, as in the *Herpnemata*, of a yellow colour.

In the *Plagiacanthidæ* or first family of the *Protodermata*, he name of which I take from the *Plagiacantha arachnoides*

* From σάρξ, flesh, and βλάστη, a growth or bud.

RHIZOPODA.

No definite nucleus *No* contractile vesicle.	Definite nucleus. *No* contractile vesicle.	Definite nucleus. Contractile vesicle.
1. HERPNEMATA.*	2. PROTODERMATA†.	3. PROTEINA‡.
Shell never siliceous.	Skeleton solid.	Pseudopodia monomorphous.
FORAMINIFERA.	PLAGIACANTHIDÆ.	ACTINOPHRYNA.
§ *Lieberkuhnia* (Clap.).	ACANTHOMETRINA.	*Actinophrys*
Pamphagus ? (Bailey).	THALASSICOLLINA ?	*Gromia.*
		Lagynis.
		Euglypha.
		Cadium (Bail.)
		Protocystis (Wal.)
		Plagiophrys ? (Clap.)
Skeleton invariably siliceous.	Skeleton tubular.	Pseudopodia polymorphous.
POLYCYSTINA.	DICTYOCHIDÆ.	AMŒBINA.
	SPONGIDÆ.	*Amœba.*
		Difflugia.
		Arcella.
		Pseudochlamys.
		INFUSORIA.

* From ἕρπω, to creep, and νῆμα, a thread.

† From πρῶτος, first or earliest, and δέρμα, skin.

‡ This name is adopted from the classification of MM. Claparède and Lachmann, inasmuch as the order so designated comprises the two families whose affinities they recognized, although on grounds which appear to me of very minor importance as compared with those now adduced.

§ See explanation of the Plate accompanying this paper, Fig. 1, and Deep Sea Researches on the Biology of *Globigerina* (already referred to at p. 270 ante); at p. 54 of which the following passage occurs:—"I may state that every fresh observation seems to lead to the conclusion that, so far from its being probable that the further extension of our knowledge of the lower forms will bring to light beings consisting absolutely of homogeneous protoplasm, more close and careful scrutiny will eventually show that *all* either have a definite nucleus or diffused nuclear masses, identical with the Sarcoblasts of the *Foraminifera*, *Polycystina*, *Acanthometræ*, &c., and with those of the *Amœbæ*," &c.

POLYCYSTINA.

Animal presenting the distinctive characters of the Herpnemata. Skeleton invariably and purely siliceous, of crystalline clearness, colourless, never tubular in any portion; continuous, so as always to form one piece only, no matter how far growth has proceeded; generally foraminated, although the apertures vary greatly in size, and the solid parts also vary from being comparatively stout to being mere threads, or a network of threads, as on the spongy forms. The interior of the skeleton more or less imperfectly divided into chambers.

DIVISION 1.

(*a.*) Omphalostype symmetrical. Omphalic chamber spherical.

CYCLODINA.

1.

(*b.*) SPHÆRODINA. Successive chambers, when more than one, arranged concentrically around the omphalic chamber, and developed upon and around the *Acanthostypes* (*f*) which originate from the omphalostype. Typical Genus, *Haliomma* (Ehr.).

2.

(*c.*) DICHODINA. Successive chambers more or less compressed, discoidal, or lenticular, but interrupted at opposite poles. Typical Genus *Amphidiscus* (Müller).

DIVISION 2.

Omphalostype not symmetrical. Omphalic chamber not symmetrical, generally more or less pyramidal.

MONODINA.

(*d.*) ACTINODINA. Successive chambers compressed, discoidal, or lenticular, concentrically arranged in a plane at right angles to the short axis, with symmetrically placed radiating lobes, varying in number from two to six, or even more, the concentric arrangement of the minute siliceous fibres being often continued into such rays. Typical Genus, *Astromma* (Ehr.).

(*e.*) MONODINA. Successive chambers arranged generally one in front of the other, in linear series; although, owing to accidental malformation the axis of the chambers may, to this extent, not maintain a direct line. Typical Genus, *Podocyrtis* (Ehr.).

a. From ὀμφαλός, the navel, and στύπος, a stem.
b. From σφαῖρα, a sphere, and ὁδός, a way or method.
c. From δίχα, in two, apart, and ὁδός, a way or method.
d. From ἀκτίν, a ray, and ὁδός, a way or method.
e. From μόνος, single, one, and ὁδός, a way or method.
f. From ἀκανθά, a spine, and στύπος, a stem.

of M. Claparède ("Monatsb." 1856, p. 500) and which is generally identical in all its characters with the *Acanthodesmia*, of Johannes Müller (1858), we have the connecting link between the siliceous structure in this Order and some of the numerous aberrant varieties of the siliceous framework of the *Polycystina*. In this family the shell is very rarely symmetrical in any of its aspects, being formed (as seen in Fig. 6) of three or more straight or branching, and sometimes very *bizarre*-looking siliceous rods or bars, united together at one or more points, so as to form a solid piece. Within the rude cavity thus formed, the bulk of the sarcode body is sustained, a delicate investing layer being, however, as in the former case, extended exteriorly over the framework. Nucleus and sarcoblasts as described in the general characters of the order. To this family will be found to belong those strikingly curious forms in which the tendency to unsymmetrical growth attains the greatest limit, and which are known under the names of *Dictyospyris*, *Stephanolithis*, *Cladococcus*, *Stylocyclia*, and *Acanthodesmia*.

In the *Acanthometrina* there exists a much more complex, generally perfectly symmetrical, and beautiful arrangement of the siliceous skeleton, which in all the true *Acanthometræ* consists of a varying number of radiating spicules, disposed in pairs, and uniting at the central axis of the structure merely by close juxtaposition of their conical-shaped bases. Occasionally the spines are blade or oar-like—occasionally furnished with hilt-like processes placed at some little distance from their axial point of union; and when these processes so far extend themselves as to coalesce with those of the spicules next to them, they form perforated chambers often resembling those of some of the Polycystine *Haliommata*. The nuclear mass is, in the *Acanthometræ*, not enclosed within a mere membranous chamber, but around the point of junction of the spines, which it accordingly more or less completely embraces and conceals. In the very early stage of *Acanthometræ*, the development of the spines takes place at the central point of the sarcoblast, and the spines as they grow gradually push the investing nuclear capsule (which is also developed in a very distinct form at this early period of the organism's history), before them, just as the finger may push before it a glove-like process of thin india-rubber. In all probability the spines, after a certain time, cause the rupture of the nuclear capsule, which causes it to hang from their extremities in curtain-like festoons. It is extremely tough, however, and so hyaline that the structure within, until the nuclear mass is reached, is plainly visible. The sarcoblasts are, apparently, not quite so numerous in the *Acanthometræ* as i[illegible] *oraminifera* and *Polycystina*. But in all other [illegible]y are identical.

It is the prevalent opinion, originated by Müller, and adopted by all later writers without exception, that the spines of the *Acanthometræ* are *tubular*, and that processes of the sarcode pass through the tubules and show themselves at their apices in the shape of pseudopodia. This, I have long since tried to show, is altogether an error, resulting from the high refractive quality and the *imperfectly* siliceous nature of the material of which they are composed in this family alone of the *Protodermata*, and in one or two curious free-floating Polycystina; the illusory appearance of tubularity being caused by the longitudinal ribs or flanges which are present in most spines, and when looked at, under the microscope, on one or other of the faces upon which they naturally take up their position, give the appearance of the spines being hollow. Just in like manner in certain genera the spines are apparently truncate and cleft in half at their extremities by a deep angular notch like the letter V. But so far from this being, as alleged by Müller and others, a cleft, the V is formed by the rectangular spines having a small portion of their ends cut off from opposite *angles* in such wise that a "knife-edge" is produced diagonally from corner to corner; the intensely hyaline nature of the material preventing the *knife-edge* being seen, except under the best illumination and under the use of very high magnifying power.

I may remark also that it was long ago pointed out by me that the reason why the spines of the *Acanthometræ*, which abound in the surface waters of the ocean, are never found in the deep sea deposits, is that owing to this imperfectly siliceous character, they become dissolved before they reach the bottom. This opinion has also been very recently adopted by Sir Wyville Thomson. (See Figs. 7, 8, 26, 26 *a*, 26 *b* and 27.)

Of the *Thalassicollidæ*, it is unnecessary for me to give any further description here than I have already given in the body of my paper; inasmuch as they are, under any circumstances, a very aberrant group; and any attempt to picture their characters is calculated, in my opinion, rather to increase than diminish the difficulties which surround the history of these lower forms of animal life.

The *Dictyochidæ* are also an aberrant family, to this extent, that their siliceous framework is invariably, and in every part, tubular. It consists also invariably of two perfectly distinct but symmetrical and equal-sized basket-like portions, within the cavities of which the bulk of the body-substance is contained, and by it protected. A *Dictyocha* may therefore be regarded as a symmetrically formed *Plagiacantha* or *Acanthodesmia*; with this difference, that the framework of each individual is tubular, like a sponge spicule, and always composed of two symmetrical and equal pieces, instead of one unsymmetrical one.

As the *Dictyochidæ* have often been met with by me in tropical seas, grouped together in numbers in a common sarcodic matrix, and they possess the characteristic tubularity of which I have spoken, it appears to me that they form the only true connecting link between the Rhizopods and the Sponges.

It has already been shown by me why I hold that the *Polycystina*—which have of late years been seized upon to help to build up the motley group called *Radiolaria*, are disqualified through the absence of an *encapsuled* and *definite* nucleus, from being placed in any other position amongst the Rhizopods, than with the *Foraminifera*. It is, however, only because they have been classified in like manner with the other groups arranged under the term *Radiolaria*, without any further result, so far as I can see, than to increase the list of so-called genera and species, and without due weight being ascribed to their extreme varietal tendencies: that I avail myself of the present opportunity to furnish a somewhat more complete, though necessarily brief outline of their classification and characters than has heretofore been offered by me.

In the earliest observable stage of the siliceous skeleton of the *Polycystina*, two very definite and important formations take place within the sarcoblast. These, apparently, never vary so far as to render their characters uncertain at any subsequent period in the history of the organism. To these two formations (in consequence of their extreme value for determining their typical starting-points), I have given the names of *Omphalostype* and *Omphalic chamber*. The first constitutes the axis of all future development of the siliceous structure. The latter constitutes the omphalic chamber, which answers to the primordial chamber of the closely related Foraminifera. Both are secreted, one, however, after the other within the *nucleus* and peripheral portion of the sarcoblast which produces them; the omphalostype consisting in the Symmetrical or *Cyclodinal* division of the *Polycystina*, of two, or four, rarely more, intensely delicate and minute *spinelets*, united at their bases, but upon and around the free extremities of which the first little spherical chamberlet or omphalic chamber is secreted, whilst as yet the dimensions of the sarcoblast have but very slightly increased; the second and each succeeding chamber of the series being constructed on precisely the same plan; that is to say, by the continuous growth, radially outwards of the spines, and the repetition, at stated intervals, of the formation of another perforated siliceous chamber; until at last there exists a series of gradually increasing hollow spheres, retained one within the other, and *in situ*, by the spines. In the Non-symmetrical or *Monodinal* division, the ostype consists of extremely delicate siliceous fibres,

which at once assume the shape of a crescent, inasmuch as they present a basal ring, from the upper margin of which generally three principal loops are projected upwards and convergingly in a graceful curve, until they meet at a central point where they terminate in a single spike, resembling that of a modern helmet. From the lateral aspects of the loops, the network forming the first or omphalic chamber characteristic of the *Monadina* is secreted: all subsequent growth and extension of the siliceous material taking place only from the front or opening of the crescent-like framework, no matter how many chambers may be produced. As already stated both the rudimentary spinelets and the omphalic chambers of the individual throughout the whole of the *Polycystina* as formed whilst still within the parent sarcoblast remain constant and determinable to the last, no matter how exuberant or even monstrous the growth may, and does very often, become. It is this *omphalic chamber*, and the chamber formed subsequently to it, which have very frequently been described by writers, who have seen them imbedded in the semi-transparent dead sarcode, as the *nucleus* and *nucleolus* of the *sarcode*.

In the concentrically formed division, we find certain plans of growth which might, under a cursory view, be regarded as exceptional; namely, in those examples in which the *mature* framework is not spherical, but compressed so as to assume a more or less discoidal, lenticular, or even stelliform shape. But even in these forms, and in forms in which we meet with an unmistakable admixture of different plans of growth, as if the organism had run riot from sheer exuberance of development which surrounds the central or normal portion by a network, or interrupts one plan of growth and alternates it with another, as if doubtful which would suit it best, the *omphalotype* and *omphalic chamber* remain to the last, and furnish us with the most conclusive evidence to be had, that in naming the numberless varietal forms which these beautiful structures constantly assume, any number of cabinet specimens may be identified, but not a single step will be gained in our knowledge of the causes which produce them.

EXPLANATION OF PLATE VI.

N.B.—These figures are all more or less diagrammatic, and meant only for the purpose of illustrating the main points in the accompanying paper.

FIG. 1. *Lieberkuhnia*, (Clap.), showing the central mass of naked sarcode, the pseudopodia being omitted for want of room. The object of this figure (which is a rough copy of Claparède's) is to show that in the original, *sarcoblasts* are distinctly visible. As they are not *yellow* in this genus, Claparède would seem to have failed in recognizing them as the representatives of his "yellow cells"

FIG. 2. A mass of sarcode in the chamber of a Foraminifer, a Globigerine shell, exhibiting sarcoblasts. 2 *a*, a detached sarcoblast seen without focussing down to an equatorial plane. 2 *b*, showing the same with the central nucleus of clear basal sarcode, as seen when the focussing is so adjusted as to show the equatorial plane.

„ 3. The chambers of a Rotaline shell filled with sarcode, and containing sarcoblasts.

„ 4. A *Haliomma* (a Polycystine) showing the nuclear sarcode aggregated around the internal chambers; and sarcoblasts between the nuclear mass and the inner wall of the outer foraminated spherical chamber.

„ 5. A broken shell of the same, showing the disposition of the omphalic chamber, and the second and third chambers; the spines; and the sarcoblasts within the sarcode.

„ 6. *Acanthodesmia* (Müller) showing the irregular character of the siliceous framework and the relative position of the sarcode and sarcoblasts; the nucleus being 'in the second Order' enveloped in a distinct membranous capsule.

„ 7. *Acanthometra*—illustrating the radiate arrangement, and axial point of union of the spines at their conical bases; the *nucleus* surrounding the bases of the spines for some distance, and the *nuclear capsule* (which in the early state of the organism, closely invested it) being now pushed outwards in every direction by the growth of the spines, and probably pierced by them. The sarcoblasts shown in the mass of the sarcode within.

„ 8. A young *Acanthometra*, showing the nuclear capsule already apparently pierced by the longer spines, and pushed outwards in other directions by the series of shorter spines. This is the condition which the young *Acanthometræ* usually present. The *nucleus* is not represented, being at this stage of the organism's growth scarcely visible, both from its minute dimensions and comparative absence of colour.

„ 9. A separated siliceous chamber of one of the composite *Collosphæridæ*—the perforations on which give it, at first sight, the appearance of a Polycystine shell. Within is seen the massive, often richly coloured, nucleus, its nucleolus, and its investing capsular membrane, with sarcoblasts in the sarcode between the capsule and the wall of the shell.

„ 10. The siliceous structure of *Dictyocha*, as seen from above; the *twin* siliceous framework being very faintly indicated beneath.

„ 11. Diagrammatic outline of the two basket-shaped, twin pieces, which enter into the structure of each living *Dictyocha*, the *nucleus*, *nucleolus*, *membranous capsule*, enveloping sarcode, and *sarcoblasts* being shown also.

„ 12. The *sarcoblast* of the *Polycystina*, *a*, as seen in an axial plane, in order to show the point of union at the immediate centre of the spinelets which constitute the *omphalostype* of the *Cyclodinal* division; and *b*, the appearance of the same from above.

„ 13. A sectional view of a *Haliomma*, showing a *sphærodinal omphalostype*: the *omphalic* chamber around it, two succeeding cham-

bers, and the spines. 13 *a*. The *omphalic* chamber just developed, and the projecting spines. 13 *b*. The same advancing towards the completion of a second chamber.

FIG. 14. Sectional view of one of the fenestral *Haliommata*. The *spherical omphalic* chamber shown at its centre, with spines projected from it only in one axial plane: the peripheral spines taking their rise altogether from the external surface of the shell.

„ 15. Side view of *Haliomma amphidiscus* (Müller), one of the *Dichodinal* series, showing the interrupted growth of the external chamber which is always more or less compressed. An internal chamber is seen within the outer one, and two spines extending from its long axis. Of course in this the *omphalostype* could not be represented. But if seen, it would invariably be of the perfectly spherical form characteristic of the *Cyclodinal* division.

„ 16. A *Haliomma*—showing the second chamber—within which is seen the spherical *omphalic* chamber, and the four spines. From the long axis of the shell, two of the delicate internal spines are shown suddenly increasing in massiveness. This condition is of very frequent occurrence.

„ 17, 18, 19 are various beautiful and not uncommon kinds of radiate *Astrommata* of the *Actinodinal* series, in which the growth of the structures, (owing to the almost endless number of varietal and overlapping forms they assume) appears after the formation of the omphalic chamber and the one succeeding it, to diverge from the primary plan of growth in almost any direction.

„ 20. A not uncommon Polycystine form, met with at the surface of tropical and subtropical seas, in which the shell is so imperfectly siliceous as to yield to pressure, and sometimes even to become distorted without fracture occurring. The material, however, is not at all highly refractive, as is the case with the Acanthometrine spines.

„ 21. Represents another not unfrequent Polycystine shell from the same seas, but which is perfectly siliceous. Whether these two last represented forms are as closely allied as they appear to be, cannot be determined until the animal of the imperfectly siliceous form shall have been carefully examined in a recent state.

„ 22. *Pterocanium*—one of the *Monodinal* series in side view, showing the spike-like spine, the rudiment of which was formed at the apex of the *omphalostype*; and has since then only increased in thickness and length. The *omphalic* chamber is seen supporting it, but, of course, very greatly extended outwards in diameter and thickness.

„ 23. The same as seen from the lower aspect. The aperture is more frequently almost as large as the diameter of the shell at this point, but occasionally, as in the specimen figured, the deposit of silex has gone on until the main opening is very little larger than the surrounding perforations in the shell.

„ 24. Gives an enlarged view of a *Monolin*
occurs in the form depicted in the fi

FIGS. 25, 26, and 27 give diagrammatic but correct transverse *sectional* views of common forms of Acanthometrine spines, in order to show the ribbed or flange-like structure which engenders the appearance of tubularity in these spines, in consequence of the rib or flange-like portion extending longitudinally along the centre of the spines.

„ 28, 28 *a*, and 28 *b* are diagrammatic representations of the truncate *Acanthometrine* spines, presenting the *split* appearance, 28 *b* showing the *split* when the object is not viewed under a sufficiently high magnifying power, in a suitable medium, or under imperfect illumination. Fig. 28 shows the same, when proper definition is secured.

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EUCALYPTUS GLOBULUS.

THE EUCALYPTUS GLOBULUS.

By M. BETHAM EDWARDS.

[PLATE VIII.]

IN one of the stormiest years on record, 1792, when the French Republic was proclaimed, the unfortunate Louis XVI. arraigned before the Assembly, and all Europe armed itself against France, a momentous discovery was made by a French naturalist named Labillardière. A few years earlier, a grand scientific expedition had been started under royal auspices and the direction of the famous navigator La Pérouse; but as nothing had been heard of it since 1788, the National Assembly dispatched two ships in search of the missing vessel. Thus came about the discovery of the now famous *Eucalyptus globulus*. The fever-destroying, health-giving Australian Blue Gum Tree, or Eucalyptus, destined three generations later to transform miasmatic plains and fever-breeding marshes into healthful resorts, to alleviate moreover some of the worst ills which flesh is heir to, and further to open countless sources of wealth and industry, may be regarded as an offspring of the great French Revolution. Very probably Labillardière, with the prescience of true genius, foresaw many of the important results of his treasure-trove, but all were far beyond human sagacity to predict. Could he in spirit now transport himself from one Eucalyptus plantation to another—from Algeria to Ceylon, from the Cape of Good Hope to Spain, from New Zealand to the Riviera; could he compare the aridness and unhealthfulness which had been with the verdure and salubrity now existing, he might indeed feel a thrill of pride and gratitude for the benefits conferred by his agency upon mankind. Could he know how the ships now crossing each other on the great ocean highways transport precious bales of Eucalyptus seed to all parts of the world, destined to make far-off wildernesses blossom as the rose, he might indeed exclaim in the words of the Roman poet:—

Quæ regio in terris nostri non plena laboris!

Labillardière thus describes his discovery, made in Van Diemen's Land, on May 12, 1792: "The Eucalyptus, one of the loftiest

objects in nature, only bears flowers towards its ummit. The trunk is suitable for purposes of naval construction, and would serve for masts, though not so light and elastic as that of the pine. We were obliged to fell one of them in order to procure the flowers. The sun was then very hot, and the sap rose to the surface abundantly. This handsome tree, of the myrtle tribe, has a thin bark; the branches curl a little in shooting upwards and, have alternate leaves, slightly curved. The bark, the leaves, and the fruit are aromatic, and might be substituted for those of other trees hitherto supplied by the Molucca islands." He named the tree, then known only as the Blue Gum Tree, *Eucalyptus globulus*, *εὐκάλυπτος* (meaning, in Greek, well hidden), from the shape of the calyx; and *globulus*, (Lat., a button), from the likeness of its fruit to a coat-button.

When we consider the stately height of the Eucalyptus we need not wonder that it attracted Labillardière's attention. Specimens have been seen lofty enough to tower over Strasburg Cathedral and cast a shadow on the Pyramid of Cheops!

Visitors to Kew, perhaps, seldom pause to study the tall, slender, bluish-green trees so conspicuous in one of the glass houses, or imagine the important part they are destined to perform in the history of the world. To see them in full glory we must visit Tasmania, where these giants of the forest world surpass in height the towering Wellingtonias of California; but along the coast of the Riviera, in Spain, in South Africa, and in Algeria they cannot fail to attract the attention of travellers. In England very few experiments have been successful, though occasionally, as in gardens at Dulwich Common, are seen flourishing young trees of a year's growth already a yard in height. This is to be accounted for by the mildness of the late winter season. When planted in glass houses they spring up with such rapidity that none are lofty enough to hold them, and every year they have to be lopped, to the great detriment of their general appearance. Opinions vary much as to the beauty of the Eucalyptus. Whilst some writers enthusiastically extol it, as one of the most conspicuous ornaments of the vegetable world, others consider it as acceptable only on utilitarian grounds, and having no claim whatever to comeliness, much less grace. A mean is to be drawn between these two views, the Eucalyptus having certainly outward attractions, though in far inferior degree to the elm, the oak, and the birch. The flowers of some species are particularly lovely and the seed-vessel very curious.

Madame Bodichon, writing in the *Pall Mall Gazette*, thus describes a young Algerian-Australian Eucalyptus forest visited in 1874: "On M. Trottier's estate at Hussein Dey we walked under tall trees on an average fifty feet high, which, seven years ago, were planted with seeds not so big as a mustard-seed. This

particular plantation was on bad soil, and had not received any experienced care, yet the growth of the trees was truly marvellous. In this evergreen wood all round us were tall, reddish, smooth stems, with the bark hanging down in a ragged, untidy manner —for the tree sheds its bark in winter—and grey willow-like leaves waving on flexible boughs. For about twenty-five feet the stems of the trees in the inner part of the plantation rose up with no branches at all; but in the outer part of the wood the trees sent out branches in the light and air nearly touching the ground. It produced a curious impression to walk in the dim twilight of this Australian-African forest, and to think that this was also a wood of the Miocene period. Beautiful is not the word I should apply to its appearance; but, in exchange for bare, sun-baked earth, or deadly swamps, I must say these Eucalyptus forests are most grateful, and the smell delightfully resinous, warm, and gummy. The multitude of birds in the branches and their busy twitterings added much to the pleasant impression. I measured these trees as I walked along, and found them forty to forty-five inches in circumference; those on the borders of the wood always, of course, a few inches larger. The flower of the Eucalyptus tribe is very like the myrtle flower; it is full of honey, and attracts a multitude of flies and bees; and the birds naturally follow, for they find not only food, but thick, warm, leafy cover in winter, and shelter from the burning sun in summer. Some species of the Eucalyptus have large and very beautiful flowers; we noticed with delight the gorgeous, red, and staminous flower of the *E. tetraptera* bursting the pyramidal top of its square-sided flower-box."

An interesting communication regarding the Eucalyptus in South Africa has been forwarded to me by J. Mountfield Bennett, Esq., of Mountfield, Sussex: "I have often seen the *Eucalyptus globulus* in South Africa. It does not do well on the coast, as has also been found in Jamaica, where it was only introduced six years ago, and trees are already found there sixty feet high. Up the country in South Africa, fifty miles N.W. round Pieter-Maritzburg, we find it growing to perfection. There are plantations of it all over that district. I was staying for six months at one of these, the property of Mr. Simmons, Secretary of State, who has twenty acres planted with trees. The great drawback to cultivators in South Africa is the liability of Eucalyptus plantations to destruction by fire when the grass is burnt, which is done once a year in the Velt. Round every Boer's house you may see this tree growing from a great distance. When one is lost, as I know from experience, it is the gladdest sight a sportsman can see, their dark foliage always assuring him a night's lodging. Through the Transvaal the houses always have a few of them round the gardens. I may add that it is

said this tree never grows in South Africa from the seed dropping in a natural way; it must be gathered and sown, and when planted out must be put in the same kind of locality in which it grew in the seed-bed."

In a photograph of Pieter-Maritzburg before me it is easy to distinguish the young Eucalyptus trees from the peach and other trees growing so plentifully around the snug-looking settlers' houses. They shoot upwards, like the cypress, with a slender stem, and in the photograph have a curiously artificial look.

The weird majesty of a Eucalyptus in its native land is glowingly described by the accomplished authors of "What we Saw in Australia." They found in South Australia little variety of foliage except the gum trees, red, white, and blue; these, however, vary so much in different periods of growth, in different positions, and under different lights, that they produce very nearly the effect of stone pines, firs, elms, oaks, and especially willows. Isolated trees are found as handsome in form as our finest oaks and elms, which look dwarfed by their side. When an enclosure is cleared the trees are "ringed," i.e., stripped of their bark, in order to facilitate decay, and the aspect then presented by them is sombre in the extreme. "We often," write our authors, "passed these strange plantations; and if there chanced to be a leaden sky, throwing the skeleton-like branches into strong relief, or a heavy rain blurring and blotting out the gaunt outlines, it was difficult not to believe that we were among beings of another world." The blue gum, or *E. globulus*, is not yet abundant in South Australia. The red gum tree makes excellent fuel; the white burns, but gives little heat.

The genus *Eucalyptus* belongs to the order Myrtaceæ, and numbers about 150 species, of which about fifty are being naturalized in Algeria. Leaves of a certain fossil species have been discovered in several places in Switzerland, the beds belonging to the Miocene epoch. At Monte Bolca, in North Italy, three species have been discovered in strata of the Eocene epoch. So far as is yet known, no trace of the genus *Eucalyptus* has been found in any part of Britain.

The best descriptions of *Eucalyptus globulus* are to be found in Sir J. Hooker's "Fl. Tasmaniæ," vol. i., and in Baron Müller's "Fragmenta Phytographiæ Australiæ;" but such accounts of it as are to be found in Bentley's "Handbook of Botany" and other works of the kind will suffice for the ordinary reader.

A long gap follows in the history of the Eucalyptus after Labillardière's discovery, only occasional specimens attracting the notice of arboriculturists, who often cultivated them without knowing what they were. In England, otherwise so abundantly supplied with specimens of the Australian flora, no attention was

to it till within the last few years; and in a glass house ging to the Botanical Museum of Paris, so late as 1854, a men was exhibited under a wrong name. In Tasmania, on ontrary, its divers uses and economic properties were early ciated; but the real history of the Eucalyptus dates from foundation of the colony of Victoria, about a generation a half ago. The learned director of the Melbourne Bo- al Gardens, Baron Müller, German by birth, Anglo-Australian turalization, whose name will ever be associated with that of Eucalyptus, first set to work on the noble task of propaga- finding in M. Ramel, a French merchant, an equally zealous ee to the same cause; and it is mainly owing to their con- efforts in the first instance that this anti-febrile tree, *par lence*, is now spread far and wide. M. Ramel happened to Australia on business, and noticed in the public gardens of ourne a conspicuous young tree, of which he knew neither ame nor the family. "But," he writes, "I was struck by egance, and it became straightway an object of interest to He carried some seeds back to France with him, which at once planted, and the extraordinarily rapid growth of edlings excited no little curiosity. In some cases they shot rds at the rate of a yard in a few months, while their grace- uish-green foliage made them agreeable additions to public ns. M. Ramel, a man of business and no botanist to begin addicted himself to the Eucalyptus with an ardour only in scientific research. He studied it under all its aspects, predicted the grand part it was to play in the economic ry of the natural world. As one of his friends has written, lieved in the Eucalyptus as optimists believe in the final ph of good over evil upon earth. In imagination he saw lains and marshes of Algeria covered with plantations and s, fever and malaria disappearing, climate and soil under- wondrous transformations, happy populations flourishing e fever, pestilence, and ill-rewarded toil had hitherto deci- d the pioneers of civilization. And, fantastical as those ns seemed to others then, they have in great part come as this history will show. Baron Müller and M. Ramel heir shoulders to the wheel, and from 1862 the planting e Eucalyptus was vigorously carried on in various places, ly in Algeria. At first saplings were transplanted from Jardin d'Acclimatation, but it was soon discovered that sowing offered the quickest and surest means of propagation. s, therefore, were sent by Baron Müller in great quantities; d. Ramel found active coadjutors in MM. Trottier, Cordier, chon, and other leading colonists. The name of the dis- uished botanist Durando will ever be associated also with this work in the *colony*. These gentlemen soon convinced

themselves that not only did the *Eucalyptus globulus* offer a source of industrial wealth to the colony as timber, but also, if planted on a sufficiently extensive scale, a guarantee against the hitherto invincible enemy, malaria. How assiduously planting was carried on may be judged by one fact. In 1862 not a single seed had been sown in Algeria, whereas at the present time we find there many hundred thousand trees, two millions having been sown and planted in the colony altogether. Large numbers have died in their early state, greater care being then required than was always given; and the Arabs also are very destructive to the young plantations, the women and children often breaking and mutilating the trees when in want of brooms or branches. These trees vary in height from fifty to sixty feet, and in some cases have been known to grow to a height of thirty yards in ten years; two yards a year is no unusual growth. Individual efforts, however, could not have brought about such large results, and the Algerian Government, as well as public companies, have seconded them in many districts. It was found that wherever the Eucalyptus was planted abundantly, sanitary conditions improved, so that alike a love of science and humanity stimulated the work.

Many species have been and are being daily tried, but at present the large plantations consist principally of the *Eucalyptus globulus*. The species *E. colosea*, which is a hardier tree in the sun than the *E. globulus*, flourishes in the desert at Laghouat. These fragrant Australian forests in the midst of African deserts now form one of the marvels of Algerian travel; but during my two visits eleven or twelve years ago the very name of Eucalyptus was only familiar to a few *savants*, and not a single tree was growing on large tracts now green and umbrageous with the familiar bluish-green foliage and slender branches.

But not in Algeria alone has the work of propagation been vigorously carried on, though the French-African colony may be regarded as the adopted country of the Blue Gum Tree. On the coast of the Riviera, in the South of France and Spain, in Corsica, in the jungles of Ceylon, in the Transvaal, and other parts of South Africa, as also in Jamaica, the Eucalyptus has been planted by the arboriculturist or the colonist, and always with the best results. A year or two ago very interesting letters appeared in a Ceylon newspaper on the effect of Eucalyptus-planting in the jungle. Wherever such experiments had been carried on to any extent jungle fever showed a perceptible tendency to diminish. Its introduction into Valencia is due to the combined efforts of M. Ramel and a countryman of our own, equally indefatigable in the same cause, Mr. Wilson. At the time of a journey made by them in Spain the malaria was raging.

Many trees were planted in the most unhealthy spots; and their value was so soon recognized by the peasants, that they would steal the leaves for the purpose of making decoctions, and called the Eucalyptus *l'arbre à la fièvre*. Now single trees and plantations are found near Seville, between Seville and Granada, at Granada and Malaga, also near Lisbon. Nice, Monaco, Hyères, Cannes can now boast of their Eucalyptus plantations, especially in private gardens, where they are highly ornamental; and the Roman Campagna, that hotbed of fever, might without doubt be considerably modified if planting were undertaken on an extensive scale. Hitherto in Italy little has been done, though Garibaldi and other leading men have greatly interested themselves in the subject. The Trappist monks in the Campagna, however, have sanified their immediate district by extensive Eucalyptus plantations, which they proudly show to visitors, stating that formerly they were constantly being stricken down by malaria, whilst now it is almost unknown. Again, a little railway station in the Var, near Cannes, was at one time so terribly unhealthy, in consequence of miasma, that the station-master had to be changed every two years. Eucalyptus trees have been planted in considerable quantities round the station, and now it is no longer necessary to make these frequent changes. It is proposed to try Eucalyptus plantations in Cyprus, and we trust the scheme may be carried out.

Among ourselves efforts to naturalize the Eucalyptus out of doors have almost always failed; and the curious must visit the glass houses at Kew to familiarize themselves with this famous tree. The cold English winters and springs kill the saplings even in sheltered situations, so that we may hardly hope to see Romney Marsh or other aguish tracts metamorphosed after the manner of Algerian plains. The Eucalyptus requires as mild a climate as the orange, its zone having now been pretty accurately defined by botanists.

It is hardly necessary to remind the reader of the sanitary effect of trees or the unwholesomeness of treeless wastes. All who have travelled will recall many instances in point—Madrid, for example, which, in consequence of its arid environment, possesses one of the unhealthiest climates in Europe. Again, in Corsica the same physical conditions have been brought about by human interposition, the once fertile plains of Niolo now being completely denuded of trees, to the great detriment of its inhabitants; whereas in the sixteenth century the whole country was covered with woods and forests.

In Italy the destruction of forests in many places has been followed by the scirocco. Professor Ansted cites in one of his works the example of a pine forest near Ravenna. The forest was cut down, and the hot wind immediately appeared; it was

replanted, and no more scirocco occurred. The mistral, in the South of France, which did not occur till after the clearing of the Cevennes—the unhealthiness caused in Alsace by the felling of trees on a large scale—the aridity of Provence, once the garden of France, due to the same causes, are all cases in point.

At the time of the Revolution, writes Michelet, began a general destruction of forests in France. Trees were sacrificed for the most trifling uses. Two pines would be felled for the making of a pair of sabots! Some curious statistics are given by another writer on the effect of trees upon population, it being shown that in some departments the population has steadily decreased since the clearing of the forests. So late as 1853 the préfet of the Basses Alpes wrote officially: "If prompt and energetic measures are not taken to prevent this destruction, we shall be able to foretell almost exactly when the French Alps will become a desert in consequence of this iconoclasm." But no instance is more striking than that of Algeria. At the time of the conquest the whole of the Sahel and a great part of the Metidja were covered with wood and scrub, which not only prevented undue evaporation from the earth, but also acted as a condenser of moisture, causing refreshing dews and rains. The destruction of forests, dating from 1845, has materially changed the atmospheric conditions in those districts, and nothing but ignorance, cupidity, and fanaticism can account for the wholesale forest-burning still witnessed in Tunis and Algeria. The Arabs are persistent incendiarists, partly because the system enters into their notions of agriculture, but chiefly to spite and injure the constantly widening circle of European colonization. Forty thousand hectares of forest were thus destroyed in the year 1865 alone. Now, it has been found by experience that the Australian Blue Gum Tree, or *Eucalyptus globulus*, answers the purpose of *réboisement*, or replanting, in Algeria better than any other at present known, and many leading colonists, as we have seen, have brought wealth, science, and philanthropy to bear on the question. Foremost of these must be named M. Trottier, who claims pre-eminence for the Eucalyptus, on sanitary as well as economic grounds, seeing not only in its anti-febrile and climatic properties the surest remedy for malaria, but in the valuable quality of its timber a perpetually increasing source of wealth to the colony. In his various pamphlets, severally entitled "Influence des arbres sur la pluie," "Notes sur l'Eucalyptus," "Rôle de l'Eucalyptus en Algérie," &c., these matters are fully dealt with, and his conclusions may be summed up as follows:—The results of special observations made by the pluviometer show that forests draw down a greater abundance of rain than cultivated land; that even under trees the water reaching the

soil is larger in bulk than that falling upon unsheltered ground; in fact, that it is by means of large plantations that hot, dry climates are moistened and made habitable for Europeans. Secondly, M. Trottier brings abundant evidence to prove that of all other trees the Eucalyptus is best adapted for bringing about the physical change so necessary in Algeria, the aromatic odour of its leaves possessing strong anti-febrile qualities, whilst its timber, bark, and oil open up new sources of wealth and industry. Thirdly—and this is a vital point in the question at issue—it is unrivalled for its swiftness of growth. Large numbers are found in the South of France, partly because the elegance of the tree and the abundance of shadow make it desirable in private gardens, but chiefly because none other springs up so fast. You build your villa, sow your Eucalyptus seeds, and in seven years' time may expect to see a flourishing grove of forest trees fifty feet high. In some cases they have been known to reach a height of thirty yards in ten years, and two yards a year is no unusually rapid growth. There is something extremely fascinating in results so rapid and on so large a scale. Here indeed we do not plant trees for posterity, but for ourselves; and, granted favourable conditions, with a packet of seeds no larger than a mustard-seed, we may confidently look forward to the enjoyment of our forest in a few years; a forest, moreover, not only ornamental but useful, attracting the birds and the bees, and dispensing healthful influences around. Opinions vary as to the manner in which these sanitary influences are effected. The aromatic oil or essence distilled from the leaves may be compared to camphor, peppermint, and other antiseptics, whilst the bark possesses many of the qualities of quinine.

A very large number of experiments have been made in support of these theories, with almost invariable success. M. Trottier cites his own farm as an instance of the anti-febrile properties of the Eucalyptus, where, except in two cases, mainly owing to imprudence, no fever had occurred since the growing up of his plantations. Consul Playfair's report for 1877, quoted in the *Times*, mentions a single mining company having planted 100,000 trees at Mokta-el-Hadiet. Previously the workmen could not remain there during the summer on account of the unhealthiness of the place; those who attempted to do so died, and it was necessary to convey the labourers to and fro by rail every morning. Since the planting of the Eucalyptus the workmen are able to live on the spot all the year round. The company of military engineers alone have planted a large tract with 102,060 trees, now forming a flourishing young forest of eight years' growth. Algerian travellers who happen, like the present writer, to have traversed the plain of the Sig, in the province of Oran,

at the unwholesome season of ploughing, when the upturned soil teems with miasma, will not soon forget the fetid odour emanating from the marshy ground, nor the doom written on the faces of the people. 'The fever! the fever!' was the continual cry that rang in our ears throughout our journey; and the poor colonists begged us for quinine, which we could only give, of course, in minimum doses. Twenty years hence this same insalubrious plain of the Sig may be transformed into a region as healthful as the high grounds of Sussex or Surrey by means of the Eucalyptus.

To M. Carlotti, a Corsican doctor, we are indebted for a series of extensive and highly instructive observations in this field. During a summer and winter when intermittent fever was more common than usual in Corsica, M. Carlotti was enabled to test fully the powers of his Eucalyptus medicines, generally beginning with small doses and increasing them after renewed trials. The results obtained from infusions and decoctions of the leaves were most satisfactory. In some cases the remedy was more efficacious than quinine even, preventing a relapse, which quinine often fails to do. A fellow-countryman of Dr. Carlotti's, M. Tedeschi, was induced to follow his example, and wrote to him afterwards as follows: "I am like St. Thomas, and wished to convince myself by repeated trials before declaring my opinion. The results have been entirely satisfactory. Remember that I have never used the new medicines except in cases which quinine failed to cure. There have been failures and relapses, but the number of cures is large enough to place the decoction of Eucalyptus on a par with quinine as a tonic."

No less conclusive is the evidence of Dr. Miergues, of Bouffarik, Algeria, published in the "Science pour Tous" for January 15, 1870, wherein he gives a list of cures effected not only in human beings but animals, in the latter especially skin diseases, by means of a kind of Eucalyptus tar. For it must not be supposed that malaria, ague, and intermittent fevers are the only maladies amenable to these remedies. Dr. Miergues is the author of twenty-four medical preparations, in the form of tonics, stimulants, medicaments, plasters, powders, &c., and since that time many others have been made and are gradually getting into use. In the South of France and in Rome it is now a common practice to put a few dried Eucalyptus leaves in the light wine of the country as a tonic, and also to induce sleep in feverish patients by placing a young Eucalyptus plant near the bedside. In Algeria the medical uses of the Eucalyptus are constantly on the increase.* A few leaves put in a bath of hot

* See a paper on this subject, contributed by the present writer to the "Pall Mall Gazette"—"Medical Uses of the *Eucalyptus globulus*," January 16, 1875.

water are found to alleviate rheumatic and neuralgic pains, also the extreme debility following an attack of malaria. Lozenges are used for throat and lung disease, and there are also various specifics for other maladies in the form of cigars. As antiseptics Eucalyptus oils and soaps are exceedingly efficacious, and it is interesting to find them making way here. A chemist, on whose counter I saw some of this most fragrant soap, at Hastings, the other day, assured me that it had been in great demand for twelve months. It is especially recommended for use in the sick room.

Many specimens of these medical, and also of artistic preparations have been sent to me from Algeria, and all are characterized by a grateful fragrance, once inhaled never forgotten. I may mention *inter alia*, the sticking-plaster, tooth-powder, toilet-water, tracing-paper, oil for preserving natural and anatomical specimens, veneer, the list being too long to give entire. Naturally it is in Algeria, the adopted country of the Eucalyptus, that these investigations have been carried on with the greatest vigour, though in Paris, especially since the Algerian Exhibition, held two years ago, much interest has been excited on the subject. We may therefore expect many new and important additions to our knowledge of the resources of this wonderful tree.

It has been mentioned that Labillardière recognized the value of the Eucalyptus timber, which for hardness and durability is said to rival teak-wood. When we consider that it attains in six or seven years the dimensions of the oak in twenty, and may be expected in its twentieth year to furnish such logs of timber for shipbuilding and other purposes as could not be supplied by an oak under a hundred years old, we can understand the enthusiasm of planters. Consul Playfair, in the report already alluded to, mentions that when he wished, a short time since, to send a Eucalyptus tree four or five years old to England, its great length made it impossible to convey it in a boat to the steamer, and the boatman decided on towing it alongside. It sank, however, in the sea, and divers had to be employed in raising it. After it has been properly seasoned its specific gravity becomes less, and it then floats in water. The Consul is convinced that no other culture offers such prospects of success, provided the cultivator can afford to wait some time for his returns.

M. Trottier is the author to consult on this subject; and though his calculations read like the dreams of a visionary, they are without doubt based on scientific data. M. Carlotti, again, calculates that in planting large tracts in Corsica with Eucalyptus trees, the plantations would produce large profits in a few years; and we learn that the annual exportation of Euca-

lyptus timber from Tasmania reached, a few years ago, the large sum of 800,000*l*., which may give some idea of its value in that country. Of course the extraordinary rapidity of growth enters largely into these calculations.

Next to suitability of climate the soil has to be considered. Not only does it flourish in marshy grounds and swamps, but, as Baron Müller shows us to be the case in its native land, in dry and arid wastes, thus rendering it equally adapted to the sun-baked mountain-sides and swampy plains of Algeria. The Eucalyptus, indeed, resists the summer droughts, and profits by the rains of spring, winter, and autumn, wherever the mildness of the temperature enables it to flourish.

Specimens of Eucalyptus timber were seen at the London Exhibition of 1862, one of which measured twenty-three yards in length, with a circumference of three and a half. The best whalers cruising in the southern seas, are made of Eucalyptus wood. It is largely used in ship-building generally, and in the construction of railway sleepers, bridges, jetties, viaducts; less so in carpentry, on account of the difficulty of working it up on a small scale. Such obstacles, however, may be overcome, and we may hope ere long for a pleasing variety of art furniture in the shape of Eucalyptus upholstery. This tree, moreover, so productive of solid benefits in the shape of timber, abounds in lighter graces, attracting the birds by its ample foliage, and the bees by means of the abundant honey contained in its flowers. Formerly the bee was unknown in Australia, but it has been speedily domesticated, in consequence of the Eucalyptus flowers. Such honey should surely rival that of the far-famed Hymettus. The history of the Eucalyptus is, indeed, one of those fairy-tales of Science which fills the mind with wonder and delight. Here we have in a seed not larger than a mustard-seed not only a source of commercial wealth, and therefore national prosperity, but, what is far more important, of the health of coming generations, and the amelioration of those physical conditions in which man is compelled to live. Just as, in the intellectual history of society, the word may be a lever of immeasurable power, lifting the minds of others to higher regions of thought, enlarging man's spiritual domains, so, in the natural history of the world, the seed is a mighty agent for good, spreading beneficent influence around, revealing new scientific triumphs, bestowing undreamed of largesses on all.

Whether, therefore, we behold the *Eucalyptus globulus* in an English glass-house, or in the more favoured lands of its adoption, alike the slender sapling, with its silvery blue-green leaves, and the lofty forest tree spreading abundant shadow, affords a worthy subject of wonder and admiration. But we must remember that Nature has not done all. Were it not for the

evotedness and zeal of the first believers in the Eucalyptus, it ight still have remained a mere ornament in public gardens id conservatories. All honour, then, to those who have concrated their time, thought, and worldly goods to the cause of an's best friend, the tree!

NOTE.—The illustration appended to this sketch (Plate VIII.) is reduced e half from an original water-colour drawing by an accomplished Algerian tist, Madame Mérian.

THE EXTINCT BRITISH WOLF.

By J. E. HARTING, F.L.S., F.Z.S.

(*Concluded from* p. 269.)

Historical Evidence.—Ireland.

FROM the scanty and more or less inaccessible nature of the records relating to the natural history of Ireland, compared with what exists in the case of England and Scotland, the result of a search for materials for a history of the wolf in Ireland has proved less satisfactory than could have been wished. Nevertheless, some curious fragments of information on the subject have been collected from various sources, and are now brought together for the first time.

There is abundant evidence to show that wolves formerly existed in great numbers in Ireland, and that they maintained their ground for a longer period there than in any other part of the United Kingdom. In bygone ages they must have fared sumptuously amongst the herds of reindeer and Irish elk, which at one time were contemporary with them; and the discovery of numerous skeletons, often entire herds of deer, imbedded in the mud of ancient lakes, has led to the surmise that these animals probably perished in this way in their attempts to escape from packs of pursuing wolves.

Giraldus Cambrensis, who lived in the reigns of Henry II., Richard I., and John, and who visited Ireland in 1183 and again in 1185–6, when he accompanied Prince John there, has left a curious account of the wild animals then existing in Ireland, amongst which is included the wolf. He adds, "the wolves often have whelps in the month of December, either in consequence of the great mildness of the climate, or rather in token of the evils of treason and rapine, which are rife here before their proper season."*

* "Topographia Hiberniæ," lib. ii., cap. xxvi., p. 726. Ed. Dimock, vol. v., p. 112. And not only wolves, but crows and owls had young at C[illegible] Tom. cit., p. 112.

In the "Polychronicon" of Ranulphus Higden, the monk of Chester, who died about 1360, we have a later account of the Irish fauna, and in this also the wolf figures. Thus he says:—"*Terra hæc magis vaccis quam bobus, pascuis quam frugibus, gramine quam grano fecunda. Abundat tamen salmonibus, murænis, anguillis, et cæteris marinis piscibus; aquilis quoque, gruibus, pavonibus, coturnicibus, niso, falcone et accipitre generoso. Lupos quoque habet, mures nocentissimos; sed et araneas, sanguisugas, et lacertas habet innocuas. Mustelas quoqu parvi corporis sed valde animosas possidet.*"* This passage is thus rendered by his translator, John Trevisa (A.D. 1357–1387), and adopted by Caxton in his "Cronycles of England," 1480:—"In this lond beeth mo kyn than oxen, more pasture than corne, more grass than seed. There is grete plente of samon, of lampreyes, of eles, and of other see fisch: of egles, of cranes, of pekokes, of corlewes, of sparhaukes, of goshaukes, and of gentil faucouns, *and of wolfes*, and of wel shrewed mys. There beeth attercoppes, blood-soukers, and enettes that dooth noon harm," &c.† Some translators and later copyists have here and there singularly perverted the original meaning of this passage by blunders and mistranslations. Amongst these may be mentioned the author or authors of "The Book of Howth," a small folio in vellum of the sixteenth century, written in different hands, and preserved amongst the Carew MSS. (vol. 623), in the Lambeth Library.‡

Campion, whose "History of Ireland" was published in 1570, refers to the chase of the wolf there with wolf-hounds. "The

* "Polychronicon Ranulphi Higden, Monachi Cestrensis." Ed. Babington (Master of the Rolls Series), vol. i. pp. 334, 335.

† Some little interest attaches to this passage from the curious assemblage of animals named in it. At the period referred to "Cranes" seem to have been common enough in Ireland: "*in tanta vero numerositate se grues ingerunt, ut uno in grege centum, et circiter hunc numerum frequenter invenias*" (Topog. Hibern. Ed. Dimock, v. 46). By "pekokes" (*pavonibus*), it would seem the Capercaillie is intended. "*pavones silvestres hic abundant,*' says Giraldus (tom. cit. p. 47). "*Coturnicibus*" should be rendered "quails," not "curlews." "*Mures nocentissimos*" are not necessarily shrew-mice, which are insectivorous. In all probability that destructive field-mouse, the short-tailed Vole, *Arvicola agrestis*, is referred to. By reading "araneos" (shrews) for "araneas" (spiders), some confusion is accounted for. "Attercoppes" is the translation of *araneas*. Jamieson, in his "Scottish Dictionary," gives "Atter-cap," "Attircop," spider, with two variants—Northumberland, "Attercop," and Cumberland, "Attercob," a cobweb. A. S. atter coppe, from atter, *venenum*, and copp, *calix*; receiving its denomination partly from its form, and partly from its character; *q.* a cup of venom. By "Bloodsuckers," of course, leeches are meant: for "enettes" *lacertas*, we may read "euettes" or "evettes," i.e. efts, that do no harm.

‡ *cf.* Brewer and Bullen, Calendar Carew MSS., "The Book of Howth," p. 31.

Irish," he says, "are not without wolves, or greyhounds to hunt them; bigger of bone and limme than a colt." *

Sir James Ware, in his "Antiquities of Ireland" (1658), notices "those hounds which, from their hunting of wolves, are commonly called 'wolf-dogs,' being creatures of great strength and size, and of a fine shape."

Ray has described the Irish wolf-dog as a tall, rough greyhound; so also has Pennant, who descants at some length on his extraordinary size and power.

In a privy seal from King Henry VIII. to the Lord-Deputy and Council of Ireland, † his Majesty takes notice of the suit of the Duke of Albuquerque, of Spain (of the Privy Council to Henry VIII.), on behalf of the Marquis Desarrya and his son, "that it might please his Majesty to grant to the said Marquis and his son, and the longer liver of them, yearly, out of Ireland, two goshawks and four greyhounds," and commands the Deputy for the time being to order the delivery of the hawks and hounds, and to charge the cost to the Treasury.

In November, 1562, as we learn from the State Papers relating to Ireland, ‡ the Irish chieftain, Shane O'Neill, forwarded to Queen Elizabeth, through Robert Dudley, Earl of Leicester, a present of two horses, two hawks, and two Irish wolf-dogs. In 1585, Sir John Perrott, who was Lord-Deputy of Ireland from January, 1584, to July, 1588, § sent to Sir Francis Walsingham, then Secretary of State in London, "a brace of good wolf-dogs, one black, the other white."

Again, in 1608, we find that Irish wolf-hounds were sent from Ireland by Captain Esmond, of Duncannon, to Gilbert, seventh Earl of Shrewsbury. ||

These dogs were considered very valuable, and were highly thought of by those who received them as presents; but some years later, when owing to the great increase in the number of wolves in some parts of Ireland, their services were more than ever required to keep down these ferocious animals, a law, presently to be noticed, was passed to prohibit their exportation.

In Robert Legge's "Book of Information," compiled in 1584 by order of Sir John Perrott, the above named Lord-Deputy of Ireland, "for the reformation of the civil government of that realm," it is recommended, *inter alia*, that "for the destruction of ravening and devouring wolves, some order might be had, as

* *See* also Holinshed, "Descript. Irel." 1586, and Camden, "Britannia," vol. ii., p. 1312 (Gibson's Ed.).

† Rot. Canc. Dec. 9, 36 H. 8, *dorso*.

‡ Eliz., vol. vii., No. 40, in Pub. Rec. Off.

§ Ibid., vol. cxx., No. 12.

|| "Archæol. Æliana," vol. ii. p. 226.

:n any lease is granted, to put in some clause that the tenant leavour himself to spoil and kill wolves with traps, snares, or h devices as he may devise." *

About this time, it is said, wolves committed great devasta- ı amongst the flocks in Munster. After the destruction of mallock by James Fitzmaurice, in 1591, that place is stated have become the haunt of wolves.

For some account of their ravages during Desmond's rebellion, reader may be referred to O'Sullivan's "Compendium His- iæ Catholicæ Hiberniæ," 1621 (lib. viii., cap. 6).

At a later period, according to Fynes Moryson, who was :retary to Lord-Deputy Mountjoy, and who wrote a "History Ireland from 1599 to 1603," the cattle had to be driven in night, "for fear of thieves (the Irish using almost no other ıd of theft), or else for fear of wolves, the destruction whereof ng neglected by the inhabitants, oppressed with greater mis- efs, they are so much grown in numbers as sometimes on ıter nights they will come and prey in villages and the urbs of cities." †

In May, 1594, Lord William Russell was appointed Lord- puty of Ireland by Queen Elizabeth. From entries in his 'ournal," extending from "June 24, 1594, to May 27, 1597," appears that both he and Lady Russell, who accompanied him Ireland, frequently participated in the pleasures of the chase, ł amused themselves at different times with hawking, fishing, ł hunting. ‡ Under date May 26, 1596, it is recorded: My Lord and Lady rode abroad a hunting the wolf." As the ce-regal Court was then located at Kilmainham, almost within : city of Dublin, it would appear that the wolf in question s to be found at no great distance beyond the city walls.

Sir Arthur Chichester, writing to Sir John Davys, March 31, 09, in reference to the pending plantation of Ulster, inci- ntally remarks that "if the Irish do not possess and inhabit a :at part of the lands in some of those escheated countries, ne but wolves and wild beasts would possess them for many ars to come; for where civil men may have lands for reason- le rents in so many thousand places in that province, and in is whole kingdom, they will not plant themselves in moun- ns, rocks, and desert places, though they might have the ıd for nothing." §

In the reign of James I. it would seem that active measures

* Carew MSS., vol. 607, p. 115. Brewer and Bullen, Calendar of Carew SS., Eliz., p. 401.

† Moryson, "Hist. Irel.," Dublin ed., 1735, vol. ii., p. 367.

‡ Preserved amongst the Carew MSS. at Lambeth Palace, vol. 612.

§ State Papers, Ireland, in Record Office, vol. 226, 58.

were devised for the destruction of wolves in Ireland, and the following "Heads of a Bill in the Irish Parliament, 1611," will be found preserved amongst the Carew MSS., formerly in the Record Office, but now at Lambeth Palace :* "An Act for killing wolves and other vermin, touching the days of hunting, the people that are to attend, who to be their director, an inhibition not to use any arms. The Lord Deputy or Principal Governor to prohibit such hunting if he suspect that such assemblies by colour of hunting may prove inconvenient." This proposed act, however, seems never to have become law, for no mention of it is made in the eight volumes of Irish Statutes published by authority in Dublin in 1765. It is not surprising therefore that the ravages of the wolves in Ireland continued. In 1619 their numbers in Ulster compelled people "to house their cattle in the bawnes of their castles, where all the winter nights they stood up to their bellies in dirt. Another reason is to prevent thieves and false-hearted brethren who have spies abroad, and will come thirty miles out of one province into another to practise a cunning robbery."† In 1641 and 1652 wolves were particularly troublesome in Ireland, and in the latter year the following Order in Council was issued by Cromwell, prohibiting the exportation of wolf-dogs :—

"*Declaration against transporting of Wolfe Dogges.*

"Forasmuch as we are credibly informed that Wolves doe much increase and destroy many cattle in several partes of this Dominion, and that some of the enemie's party, who have laid down armes, and have liberty to go beyond sea and others, do attempt to carry away several such great dogges as are commonly called *wolfe dogges*, whereby the breed of them which are useful for destroying of wolves would (if not prevented) speedily decay. These are therefore to prohibit all persons whatsoever from exporting any of the said dogges out of this Dominion; and searchers and other officers of the Customs, in the several partes and creekes of this Dominion, are hereby strictly required to seize and make stopp of all such dogges, and deliver them either to the common huntsman, appointed for the precinct where they are seized upon, or to the governor of the said precinct. Dated at Kilkenny, April 27, 1652."

The following year another Order in Council was made which ran as follows :—

* Carew MSS., vol. 629, p. 35. *See* also Hamilton's "Calendar of State Papers relating to Ireland," Jac. I., sub anno, p. 192.

† Gainsford's "Glory of England," p. 148.

"*Declaration touching Wolves.*

the better destroying of wolves, which of late years have ıcreased in most parts of this nation, it is ordered that manders in chiefe and commissioners of the Revenue in ıral precincts doe consider of, use, and execute all good ınd meanes how the wolves in the counties and places the respective precincts may be taken and destroyed; ɜmploy such person or persons, and to appoint such daies ıes for hunting the wolfe, as they shall adjudge necessary. is further ordered that all such person or persons as shall ll, or destroy any wolfes and shall bring forth the head volfe before the said commanders of the revenue, shall the sums following, viz., for every bitch wolfe, six ;* for every dog wolfe, five pounds; for every cubb ɔreyeth for himself, forty shillings; for every suckling en shillings. And no wolfe after the last September ıe 10th January be accounted a young wolfe, and the ıgioners of the Revenue shall cause the same to be assessed within their precincts.

"Dublin, June 29, 1653."†

ıssessments here ordered fell heavily in some districts. December, 1665, the inhabitants of Mayo County peti- the Council of State that the Commissioners of assess- ıight be at liberty to compound for wolfe-heads; which ered accordingly.

562, as appears by the Journals of the House of Commons, n Ponsonby reported from the Committee of Grievances ɔill should be brought in "to encourage the killing of and foxes in Ireland."

ıe "Travels of the Grand Duke Cosmo III. in England," p. 103), the author speaks of wolves as common in Ire- for the hunting of which the dogs called 'mastiffs' are t request."

ıherty in his "West or H'Iar Connaught" (1684) enu- ɜ the wild animals which were to be found in that district day, and names "*wolves*, deere, foxes, badgers, hedge- ares, rabbets, squirrells, martens, weesles, and the amphi-

price paid in Sutherlandshire, in 1621, was 6*l.* 13*s.* 4*d.* *Cf. antea*,

ɜe documents were extracted from the original Privy Council Book well's government in Ireland, preserved in Dublin Castle, and are ɔy Hardiman in his edition of O'Flaherty's "West or H'Iar Con- p. 180.

bious otter, of which kind the white-faced otter is very rare." Hardiman, in a note to his edition of this work (1846), says: "When our author wrote (1684), and for some years afterwards, wolves were to be found in Iar Connaught, but not in such numbers as in the early part of that century. The last wolf which I have been able to trace here was killed in the mountains of Joyce country, in the year 1700. After the wars of 1641 the ravages of the wolves were so great throughout Ireland as to excite the attention of the State. 'Wolf-hunters' were appointed in various districts, and amongst others in Iar Connaught, who helped to rid the country of these ferocious animals."*

In an account of the British Islands, published at Nuremberg in 1690, the wilds of Kerry are referred to as harbouring wolves and foxes;† and in the reign of William and Mary, Ireland was sometimes called by the nickname of "Wolf-land." Thus in a poem on the battle of La Hogue, 1692, called "Advice to a Painter," the terror of the Irish army is described:—

> A chilling damp,
> And wolf-land howl runs through the rising camp.

"Three places in Ireland are commemorated, each as having had the last Irish wolf killed there, namely, one in the south, another near Glenarm, and the third, Wolf-hill, three miles from Belfast."‡ The one in the south is probably that referred to in Edwards's "Cork Remembrancer" (p. 131), wherein the following entry occurs: "This year (1710) the last presentment [to the Grand Jury] for killing wolves was made in the county of Cork."§ In the old "Statistical Account of Scotland," however, edited by Sir John Sinclair, it is stated (vol. xii., p. 447) that the last was killed in Ireland in 1709.

The great woods of Shillela, on the confines of Carlow and Wicklow, now the property of Earl Fitzwilliam, are said to have held wolves until about the year 1700, when the last of them was destroyed in the neighbourhood of Glendaloch.‖

In a poem, in six cantos, published as late as 1719, and entitled, "MacDermot, or the Irish Fortune-Hunter," "wolf-hunting" and "wolf-spearing" are represented as common sports in Munster. Here is an extract:—

* Hardiman, op. cit., p. 10, note.

† This work the writer has not seen. It is quoted by Macaulay, "Hist. Engl.," vol. iii., p. 136.

‡ Thompson, "Nat. Hist. Ireland," vol. iv., p. 34.

§ *See* also Scouler, 'Journ. Geol. Soc.,' Dublin, vol. i., p. 226.

‖ Mackenzie's Natural History, p. 20. This volume, published in London in modern times, is undated.

It happen'd on a day, with horn and hounds,
A baron gallop'd through MacDermot's grounds,
Well hors'd, pursuing o'er the dusty plain
A wolf, that sought the neighbouring woods to gain:
Mac hears th' alarm, and, with his oaken spear,
Joins in the chase, and runs before the peer,
Outstrips the huntsman, dogs, and panting steeds,
And, struck by him, the falling savage bleeds.

The crest of the O'Quins of Munster is "a wolf's head, erased, argent," possibly perpetuating the prowess of some former noted wolf-hunter in that ancient family.

The author of "The Present State of Great Britain and Ireland," printed in London in 1738, wrote at that date, "Wolves still abound too much in Ireland; they pray for the wolves, least they should devour them."

In Smith's "Ancient and Modern State of the County of Kerry," 1756 (of which book Macaulay said, "I do not know that I have ever met with a better book of the kind and of the size," "Hist. Engl.," iii. 136), the author, speaking of certain ancient enclosures, observes (p. 173) that "many of them were made to secure cattle from *wolves*, which animals were not entirely extirpated until about the year 1710, as I find by presentments for raising money for destroying them in some old grand-jury books."

Traces of old circular entrenchments, into which cattle and sheep were driven for protection from wolves, are still to be seen in many parts of Ireland, especially in the south. One of these, in the county Tyrone, will be noticed presently.

In Harris's edition of Sir James Ware's "Works" (Dublin, 1764), the editor, commenting upon the passage, "I shall but just hint at the eagerness of the Irish in the chase, as in hunting wolves and stags," remarks in a footnote (p. 165), "So said in the year 1658. But there are no wolves in Ireland now." This statement in turn may be controverted, upon very respectable authority, but the conflict of evidence renders it very difficult to fix with certainty the precise date at which the animal became extinct.

The following account is given of the destruction, by a noted wolf-hunter, of the last wolves in the county Tyrone.

"In the mountainous parts of the county Tyrone, the inhabitants suffered much from wolves, and gave as much for the head of one of these animals as they would now give (1829) for the capture of a notorious robber on the highway. There lived in those days an adventurer who, alone and unassisted, made it his occupation to destroy those ravagers. The time for attacking them was at night. There was a species of dog kept

for the purpose of hunting them, resembling a rough, stout, half-bred greyhound, but much stronger.

"In the county Tyrone there was then a large space of ground inclosed by a high stone wall, having a gap at the two opposite extremities, and in this were secured the flocks of the surrounding farmers. Still, secure though this fold was deemed, it was entered by the wolves, and its inmates slaughtered.

"The neighbouring proprietors having heard of the noted wolf-hunter above-mentioned, by name Rory Carragh, sent for him and offered the usual reward, with some addition, if he would undertake to destroy the two remaining wolves that had committed such devastation. Carragh, undertaking the task, took with him two wolf-dogs and a little boy, the only person he could prevail on to accompany him, and, at the approach of night, repaired to the fold in question.

"'Now,' said Carragh to the boy, 'as the wolves usually attack the opposite extremities of the sheepfold at the same time, I must leave you and one of the dogs to guard this one, while I go to the other. He steals with all the caution of a cat; nor will you hear him, but the dog will, and will positively give him the first fall. If you are not active when he is down, to rivet his neck to the ground with this spear, he will rise up and will kill both you and the dog.'

"'I'll do what I can,' said the boy, as he took the spear from the wolf-hunter's hand.

"The boy immediately threw open the gate of the fold, and took his seat in the inner part, close to the entrance, his faithful companion crouching at his side and seeming perfectly aware of the dangerous business he was engaged in. The night was very dark and cold, and the poor little boy being benumbed with the chilly air, was beginning to fall into a kind of sleep, when at that instant the dog, with a roar, leaped across him and laid his mortal enemy upon the earth. The boy was roused into double activity by the voice of his companion, and drove the spear through the wolf's neck, as he had been directed; at which time Carragh made his appearance with the head of the other."*

In an interesting article on the Irish wolf-dog, published in "The Irish Penny Journal" for 1841 (p. 354), the writer says:†

"I am at present acquainted with an old gentleman between eighty and ninety years of age, whose mother remembered wolves to have been killed in the County of Wexford about the years 1730–40, and it is asserted by many persons of weight

* "The Biography of a Tyrone Family" (Belfast, 1829), p. 74.

† This article, published under the initials of H. D. R., has since been admitted to have been written by H. D. Richardson, author of "The Dog: its Origin, Natural History, and Varieties," in which work it has been embodied with additions, 1848.

veracity that a wolf was killed in the Wicklow mountains ecently as 1770."

few years since, Sir J. Emerson Tennent wrote to a con- porary on this subject as follows:—

Waringstown, in the county Down, on the confine of the nty of Armagh, takes its name from the family of Waring, ch, in the reign of Queen Mary, fled to Ireland from Lan- ire to avoid the persecution of the Lollards. At the close he seventeenth century the Waring of that day was a mem- of the Irish Parliament; and his eldest son, Samuel Waring, born about the year 1699, and died at a very advanced age 793. He was succeeded by his nephew, the Very Reverend t Waring, Dean of Dromore, who was born in 1766, and m I had the honour to know. With him I happened to be elling through the Mourne mountains, in the county of rn, on our way to the Earl of Roden's, about the year 1834 835, when the conversation turning upon the social condition reland in the previous century, he told me that a foal be- ging to his uncle had been killed by a wolf in the stable at ringstown, and that he, when a boy, had heard the occurrence eatedly adverted to in the family circle. The dean was a of singularly acute mind and accurate memory, and unless statement of his be altogether a delusion, this would seem e the last recorded appearance of a wolf in Ireland."

he last piece of evidence collected has reference to a com- nication which appeared in "The Zoologist" for 1862 7996), under the heading, "Wolf Days of Ireland." On lying to the writer, Mr. Jonathan Grubb, of Sudbury, for her particulars, he obligingly replied in a letter, dated e 6, 1877, as follows:—

I am now in my seventieth year. My father, who was born 767, used to tell the wolf stories to us when we were children. mother—my grandmother—related them to him. She was in 1731. Her maiden name was Malone; and her uncles, whom she received her information, were the actors in the es described, at Ballyroggin, county Kildare. She remem- d one of them, James Malone, telling her how his brother e home one night on horseback pursued by a pack of wolves, overtook him, and continued leaping on to the hind quarters is horse till he reached his own door, crying out, 'Oh! es, James! my horse is ate with the wolves.'"

he precise date of this occurrence cannot now be fixed; but ems plain that wolves existed in Kildare during the first rter of the eighteenth century, and perhaps as late as 1721.

o sum up. So far as can be now ascertained, it appears the wolf became extinct in England during the reign of ry VI [illegible] it survived in Scotland until 1743; and tha

the last of these animals was killed in Ireland, according to Richardson, in 1770, or, according to Sir James Emerson Tennent, subsequently to 1766.

In the foregoing observations, no reference has been made to "were-wolves," nor has any matter been introduced touching the fabulous or superstitious aspect of the wolf's history in the British Islands. All such allusions have been purposely avoided, in order to confine the subject within reasonable limits.

Before concluding, however, we may perhaps be excused for citing so respectable an authority as Sir Thomas Browne, who, in his "Enquiries into Vulgar and Common Errors," has alluded to the popular notion that wolves cannot live in England.

In vol. iii., p. 344, of his "Works," (Wilkin's edition), he says:—"Thus because there are no wolves in England, nor have been observed for divers generations (1646), common people have proceeded into opinions, and some wise men into affirmations, that they will not live therein, although brought from other countries."

He also notices the popular belief that "a wolf first seeing a man begets a dumbness in him," a notion as old as the time of Pliny, who wrote: "*In Italia, ut creditur, luporum visus est noxius, vocemque homini, quem prius contemplatur adimere.*" In France, when anyone becomes hoarse, they say, "*Il a vu le loup.*" *

"The ground or occasional original thereof," says Sir Thomas Browne,† "was probably the amazement and sudden silence the unexpected appearance of wolves doth often put upon travellers, not by a supposed vapour or venomous emanation, but a vehement fear, which naturally produceth obmutescence, and sometimes irrecoverable silence."

A critic, adverting to this passage, has somewhat wittily remarked: "Dr. Browne did unadvisedly reckon this among his vulgar errors, for I believe he would find this no error if he were suddenly surprised by a wolf, having no means to escape or save himself!"

* Howell's Familiar Letters, vol. iv., p. 52.

† Op. cit., vol. ii., p. 422.

REVIEWS.

INDUSTRIAL CHEMISTRY.*

THIS book, although based upon Payen's *Précis de Chimie Industrielle*, has been so extensively modified and so considerably enlarged as almost to assume the form of a new work. The information contained in it has generally, although not always, been brought well up to date, and the various manufacturing processes are described with much clearness, and often with considerable detail.

The article on Sulphur includes a description of the means employed for the recovery of that body from alkali wastes by Mond's process; and that on the manufacture of sulphuric acid contains much valuable matter relative to this most important branch of our chemical industries. It is, however, to be regretted that the woodcut representing a series of sulphuric-acid chambers is somewhat antiquated, having been reproduced from a plate contained in a French edition of the original work, published nearly twenty years ago. We likewise fail to find a drawing of the ordinary pyrites kiln, now so generally in use in this country.

The production of chlorine by Weldon's process is duly described, as is also the preparation of bleaching powder in chambers; and in describing the manufacture of soda-ash, mention is made of the ammonia process, which is now being successfully carried out in this country, and which has recently taken a very extensive development on the Continent of Europe.

There are likewise valuable articles on the preservation of wood, on paper-making, soap-making, starch and sugar-making, as well as upon brewing and distillation.

The Metallurgical articles have been contributed by Dr. Paul, and are, so far as they are capable of being condensed within the limits assigned to them, generally satisfactory. Lead-smelting in the open hearth, in the reverberatory furnace, and in the blast furnace, is somewhat fully described; but at page 374, the Zeppenfeld furnace is spoken of as being still in use at Pontgibaud, whereas it has not been in operation there since 1852, and was taken down and removed early in the following year.

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* "Industrial Chemistry: Based upon a Translation of Stohmann and Engler's German Edition of Payen's 'Précis de Chimie Industrielle,'" edited throughout and supplemented with chapters on the Chemistry of the Metals, &c., by B. H. Paul, Ph.D. 8vo. London, Longmans. 1878.

Copper-smelting and the extraction of copper from burnt pyrites by the wet method, are both well epitomized; but the metallurgy of silver is not made to embrace some recent processes. The Pattinson kettles are shown with "heaters," which are now almost obsolete; and no mention is made of Luce and Rozan's steam process; while the modifications of Park's method for extracting silver from lead by the addition of metallic zinc are but briefly alluded to. These two systems have now, to a very large extent, superseded crystallization in pots and the removal of the crystals in perforated ladles. Mr. Claudet's process, by which 150,000 ozs. of silver are annually recovered from copper liquors by the addition of a soluble iodide is, however, noticed.

Dr. Paul's book, although not perfect, is in many respects superior to the original work, since not only has the chemistry of Payen been amplified and modernized, but various manufacturing processes employed in Great Britain have been supplemented to the Continental methods, chiefly given in the French and German editions. Besides this, many valuable articles have been added on the chemistry of the metals, and on the metallurgical treatment of their ores. Although, in some few cases, valuable inventions have been lost sight of, on the whole the editor has done his work very carefully, and the result is a valuable contribution to the technical literature of the country.

PHYSIOGRAPHY.*

AFTER the abundant criticism to which the latest addition to scientific terminology, represented by the word Physiography, has been subjected, Mr. Skertchly does wisely in adopting a title which is explanatory of his purpose, and which to a certain extent serves as a definition of the object he proposes to accomplish. This definition is materially aided by the quotation on the title-page which affirms that

All are but parts of one stupendous whole,

and is supplemented by a statement in the introduction, to the effect that "This volume is in one sense a manual of Physical Geography, but it differs from other works in attempting to knit the phenomena of the globe into a coherent train of reasoning. Physical Geography is too often degraded into a sort of scientific curiosity shop, in which there is a vast collection of isolated facts respecting Astronomy, Geology, Physics, Biology, and what not, without the slightest attempt at grouping them, to show how interdependent they are upon one another."

The fact is, that of late years the tendency of Science, like the impregnated ovum, has been towards fissure and constant subdivision: universal or encyclopædic knowledge has more than ever become a chimæra; and it might with more force than formerly be argued against a philosopher of the Whewell school that "Science was his forte, and Omniscience his foible."

Farseeing men, however, of Huxley's type, have realized the fact that we

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* "The Physical System of the Universe." An outline of Physiography, by B. J. Skertchly, F.G.S. Cr. 8vo., London, 1878. Daldy, Isbister & Co.

require from time to time constructive books, to balance all this Analysis: the Deductive method must be set against the Inductive: the careful collection and proper collocation of miscellaneous and disjointed observations is at least as necessary as their independent substantiation; the soldiers of the army that make war against nature must be marshalled into ranks and battalions: "*L'union fait la force.*"

Hence we have the very necessary and logical conception of the new science, Physiography. Strictly speaking it is nowise new. It was foreshadowed in the *De Rerum Natura* of Lucretius, and before that, by Aristotle and Plato; satyrized in *Tractatus de omni Scibili*, and so on; but very beautifully set before the mind in one word, Cosmos (κόσμος), by Humboldt. If Cosmos, signifying at once the LAW OF ORDER, and that concrete demonstration of this law which we behold around us in the material, perhaps even in the ultra-material, world, could be naturalized to the English language, as it has been in the more plastic and flexible German, it would serve far better than the somewhat jaunty and affected term now suggested. Physiography clashes uncomfortably with its predecessor Physiognomy, and, to the writer at least, always suggests a suspicion of photographic portraiture and *cartes de visite*, which it does not claim or deserve. But whatever be the merits or demerits of the name, the generalization is undoubtedly wanted, and will continue to be wanted from time to time as science progressively advances. Perhaps on the whole, Cosmography, now familiar to English ears, would be preferable. The essential idea involved is—an orderly review of the Systema Mundi, framed on the widest possible basis, and taking account of the latest researches in Heat, Light, and Molecular Mechanics.

On this theme, Mr. Skertchly has constructed a very agreeable and well-digested book. He states in a short preface that it owes its origin to a lecture delivered to Science teachers at the Charterhouse College, and its present publication to the fact of "the Department of Science and Art having recently become impressed with the inexpediency of teaching earth-lore as a chaotic assemblage of isolated facts."

After an introductory chapter, the writer considers in succession Matter and Motion, Light, the Sidereal and Solar systems, the Sun, the earth's internal Heat and its effects as contrasted with what is derived from external sources; leading up to what he terms "Earth sculpture." This is followed by chapters on Climate, and on the origin of Life; the work concluding with speculations upon the past and future of creation and on the finite nature of the solar system as indicated by the most recent views of the Nebular hypothesis.

The language made use of is throughout of a clear, striking and somewhat picturesque character; the main argument being elucidated by short epitomes of its essential points. As instances of lucid exposition may be named the chapters on the Precession of the Equinoxes, and on the newly discovered Repulsion from Radiation as explaining the behaviour of cometary envelopes. The conclusion of the work deserves quotation:—

"All our knowledge tends to strengthen belief in the Nebular Hypothesis under some form or another. But it may be asked, if this be true of our system, are we to stop there? The stars are suns and move in systems.

Our sun is a member of one of these. Was that grander scheme evolved from a yet grander Nebula? Who can tell? If so, how infinitely more simple would appear the unity of creation!"

W. H. STONE.

THE MOON.*

MR. PROCTOR'S works have so recently received attention in these pages, that it is hardly necessary to do more now than to record the appearance, in a second edition, of one of his best books. The present, it seems, however, is not merely a reprint, nor even an amplification of the former issue, but rather a subdivision for the convenience of non-mathematical readers.

In a short preface, Mr. Proctor says, "I have found reason to believe that portions of the original work were too difficult for the general reader. I have, therefore, removed from the present edition matter relating to details of the lunar theory (leaving the general account of the moon's motions) and also the more difficult parts of Chapter III. These will be reprinted in another volume. The last chapter on the moon's physical condition has been considerably enlarged."

W. H. STONE.

AMERICAN STATE PUBLICATIONS.

We have once more to call attention to a long series of valuable publications issued either by the Central Government of the United States, or by individual states; and we do this with a certain feeling of sadness, as we have heard a rumour that perhaps the most important of the sources to which we are indebted for this seemingly perennial spring of scientific literature, namely, the "Geological and Geographical Survey of the Territories," so ably conducted by Dr. F. V. Hayden, is about to be, if not suppressed, at least considerably shorn of its means of useful work. It is true that the liberality with which the publications of this survey have been scattered over the face of the earth might easily be construed into unnecessary profusion by legislators of economical tendencies, and it would be easy to show that many of the works have thus fallen into the hands of those who did not appreciate them, for he would need to be indeed an "all-round man" who should be equally interested by all the volumes produced; but on the other hand, we may be sure that many of the books which thus apparently go astray in the first instance, eventually find their way to the shelves of those who feel a lively interest in their contents, and thus justify the liberality with which they are distributed. On the other hand, the work done by this Survey (of the quality of which the "Atlas of Colorado" noticed below is a brilliant illustration) is so exceedingly good, and the importance of accurate information upon the natural phenomena of a new country like these western territories is so great, that we cannot imagine any valid objection being raised to the continuance of its labours. We must, therefore, express

* "The Moon, her Motions, Aspect, Scenery, and Physical Condition," A. Proctor. Second Edition. London: crown 8vo. pp. 314.

a hope that, even if it be found desirable to restrict somewhat the number of gratuitous recipients of these publications, no check will be put upon the activity of Dr. Hayden and his staff of assistants, and that we may still from time to time be able to announce the results of their researches.

How far one of the works which has reached us is to be regarded as confirmatory of the rumour above referred to we cannot tell, but the conclusion of Dr. Hayden's prefatory note sounds very like it. This book* is a quarto volume of 26 beautifully executed plates, containing numerous figures of fossil plants from the Cretaceous and Tertiary strata of the Western Territories, which, as Dr. Hayden tells us, have been engraved and printed for a period of seven years, awaiting the final report of Dr. J. S. Newberry, which was intended to form vol. VIII. of the quarto series of Survey Reports. The greater part of these plants were described as long ago as 1857, in a paper read before the Lyceum of Natural History of New York, and published by that institution in its "Annals" in 1868; so that, should the text never appear, "these plates will not be entirely lost to science," but will serve as illustrations to the descriptions published ten years ago. The names and references have been appended to the figures by Professor Lesquereux.

The splendid atlas of the Colorado Region,† lately published, is perhaps the grandest, certainly the most striking monument of the labours of the Survey over which Dr. Hayden so worthily presides. It consists of twenty large sheets, and illustrates the geological, topographical and other natural characters of an extensive district, embracing the whole of the Colorado territory and the adjacent portions of Utah, Arizona and New Mexico. Four of the maps are on a scale of 12 miles to the inch, and show the triangulation of the district, its drainage, its economic peculiarities and its general geology. In the third of these maps the arable and pasture lands, the forest and desert lands, and the mining districts are indicated by means of colours and symbols. Six geological maps, on a scale of four miles to the inch, show the geological structure of the country in more detail than the smaller one above referred to: and these same sheets, without the colours, serve to indicate the topography and orography of this interesting region, the contour lines (which also appear in the geological maps) being placed to show approximately differences of level of 200 feet. Two sheets of sections, and two of panoramic views complete the atlas, the execution of which is throughout admirable. In fact, with this atlas in his hand the student may gain a more perfect notion of the distant and wonderful Colorado region than he can readily obtain of localities much more generally known and much nearer home: and the highest honour is due, not only to Dr. Hayden and his staff, but also to the American Government authorities, under whose auspices so magnificent a work has been accomplished.

Of the "Bulletin"‡ two parts have been issued during the present year, and these, as usual, present a varied and interesting series of articles. Em-

* "Illustrations of Cretaceous and Tertiary Plants of the Western Territories of the United States."—4to. Washington, Government Printing Office. 1873.

† "Geological and Geographical Atlas of Colorado, and portions of adjacent Territories," by F. V. Hayden, U.S. Geologist in charge.—Large folio. 1873.

‡ "Bulletin of the United States Geological and Geographical Survey of the Territories," Vol. [illegible], Nos. 2 and 3, 8vo. Washington. 1873.

logical papers occupy the greater part of these two numbers, and the first of them is a most important contribution from the pen of Dr. J. A. Allen on "The Geographical Distribution of the Mammalia," in which he upholds his opinion, originally put forward in 1871, that life is distributed over the earth's surface "in circumpolar zones, which conform with the climatic zones, though not always with the parallels of the geographer." It will be seen that Dr. Allen is diametrically opposed in principle to Dr. Sclater and Mr. Wallace, whose opinions he criticizes pretty freely. His proposed primary divisions are as follows:—

I. An Arctic, or Circumpolar.

II. A North Temperate, divided into two regions and eight provinces.

III. An American Tropical, with three regions.

IV. An Indo-African, with two regions and five provinces.

V. A South American Temperate, with two provinces.

VI. An Australian, with three regions, one of them divided into two provinces.

VII. A Lemurian.

VIII. An Antarctic or South Circumpolar.

The ichthyologist will find in these two numbers some valuable notes by Dr. D. S. Jordan on a collection of fishes from the Rio Grande, and a complete catalogue of the freshwater fishes of North America by the same author.

Of entomological papers there are several, the most important of which is Dr. Le Conte's article on "The Coleoptera of the Alpine Region of the Rocky Mountains." In this paper the author remarks briefly upon the conditions which have governed the distribution of these Alpine beetles, and describes many new species belonging to various families, gives a list of coleoptera collected in the Rocky Mountains at elevations of 6,000 feet and upwards, and characterizes in an Appendix the known North American species of *Nebria*. Dr. Cyrus Thomas has some notes on orthoptera collected by Dr. Coues in Dakota and Montana, with remarks on the natural history of *Caloptenus spretus*, one of the most destructive of the North American locusts; followed by papers on the rhynchota and lepidoptera, collected at the same time by Dr. Coues, by Dr. Uhler, and Mr. W. H. Edwards. Mr. A. R. Grote contributes the first of a series of papers on North American pyralidæ, which promises to be of great value. Dr. Elliott Coues himself gives a long account of the birds observed by him in Montana and Dakota in 1873–74, in which the ornithologist will find many valuable notes on the habits of birds.

The palæontological papers in these two numbers are not numerous. Prof. Cope furnishes descriptions of new vertebrates from the Upper Tertiary and Dakota formations, chiefly mammalia and chelonia, but including also some other reptiles and species of *Graculus*, *Anser*, and *Cygnus*. Among the mammals we note a new pliocene *Auchenia* and a new genus (*Ticholeptus*) of Oreodontidæ from the Miocene of Montana. Mr. Scudder gives a preliminary notice of some of the fossil insects which he has lately obtained in such astonishing abundance from the Tertiaries of Colorado and Wyoming, including a remarkably perfect fossil butterfly, which still shows the pattern of its markings, and which he names *Prodryas persephone*, a dipterous fly

Palembolus florigerus) belonging to the family Nemestrinidæ, a Longicorn beetle (*Parolamia rudis*) belonging to a group not now represented in North America, two species of homoptera (*Petrolystra gigantea* and *heros*), which he regards as gigantic allies of our common froghoppers, a great locustid (*Lithymetes guttatus*), a slender dragon fly (*Dysagrion fredericii*), fossil masses of the eggs of a *Corydalites*, and a supposed panorpid (*Holcorpa maculosa*). Mr. Scudder also mentions the discovery by Dr. A. C. Peale, near the Green River, of fossil cases of caddis-worms, similar to those of the so-called adusial limestone of the Auvergne. The fossil bird of Florissant (see p. 321) s described and figured by Dr. J. A. Allen.

Dr. C. A. White describes some new species of invertebrate fossils from he Laramie group, and discusses the distribution of the fossils in that group, which includes the beds between the cretaceous Fox Hills group and the ertiary Wahsatch group. Prof. Calvin notices as a new member of the Devonian some dark shales discovered below the limestones of that formation t Independence in Iowa, and describes five new species of brachiopods which he regards as characteristic of this deposit. The last paper is a list of he minerals of Nevada by Dr. W. J. Hoffman.

An unpretending but exceedingly useful little book, the preparation of which must have cost its authors an immense amount of labour, is "The Bibliography of North American Invertebrate Palæontology,"* just issued s No. 10 of the "Miscellaneous Publications" of the Survey of the Territories. It contains a complete list, with references, of all works and papers elating to the invertebrate fossils of North America, from the West Indies o Greenland; and the value of the book is enhanced by the brief indications f the general nature of the contents of the articles which are generally ppended to them. This catalogue is divided into two parts, the first mbracing works published in the United States, the second those which ave appeared in British America and elsewhere. The former is prepared y Dr. C. A. White, the latter by our countryman, Prof. H. Alleyne Nicholson. The best thanks of palæontologists are due to these gentlemen or performing a task so thankless in itself.

While Dr. Hayden's operations are carried on under the auspices of the Department of the Interior, the United States Secretary of War has his own survey, namely the geographical survey west of the one hundredth meridian, under the charge of Lieut. G. M. Wheeler, the publications of which are almost as voluminous and varied as those of the older staff. The last published report of this survey is by Prof. E. D. Cope, on "The Extinct Vertebrata obtained in New Mexico in 1874,"† a quarto volume of nearly 380 pages, illustrated with 83 plates. In this valuable contribution to the palæontology of the western United States, Prof. Cope not only describes

* "Bibliography of North American Invertebrate Palæontology; Miscellaneous Publications, No. 10," by C. A. White, M.D., and H. Alleyne Nicholson, M.D., D.Sc. 8vo, Washington, 1878.

† "Report of the United States Geographical Surveys West of the One Hundredth Meridian, in charge of First Lieut. G. M. Wheeler, under the direction of Brig.-Gen. A. A. Humphreys, Chief of Engineers, U.S. Army," part II., vol. IV., Palæontology, 4to. Washington, Government Printing Office, 1877.

a great number of interesting fossil vertebrates, but also discusses the geological structure of the western slope of the Rocky Mountains and the plateau to the west of them in north-western New Mexico, in which he identifies probably Triassic strata of freshwater origin, and Cretaceous, Eocene, Upper Miocene, and Postpliocene deposits. The mesozoic fossils are very few, consisting only of a cretaceous fish apparently allied to *Mugil*, and a few triassic (?) *Crocodilia*, *Dinosauria*, and *Sauropterygia*. Besides these, Prof. Cope describes some fossil dinosaurian bones under the name of *Dystrophæus viæmalæ*, obtained from the supposed triassic rocks of south-eastern Utah. The Eocene fossils, which are from the Wahsatch formation, are much more numerous, the total number of species here described being 87, of which 54 are mammals, 24 reptiles, 8 fishes, and 1 a bird. The reptiles include species of crocodiles, lacertilia, and testudinata, the last order making up two-thirds of the whole. Among the mammalia, the carnivora, quadrumana, proboscidea, and ruminantia are wanting, and no remains of edentata or chiroptera have been found. From the consideration of the fossils, Prof. Cope is inclined to correlate the Wahsatch formation with the Suessonian of Europe (Lower Eocene). In connection with this Prof. Cope has some remarks on the origin of the various groups of mammalia by descent, accompanied by a new version of a table published by him six years ago. The Loup Fork formation, which Prof. Cope correlates with the European Upper Miocene, has furnished him with 34 species of vertebrata in the marls of Santa Fé in New Mexico, two of them being tortoises, three birds, and twenty-nine mammals. From Prof. Cope's point of view these mammalia exhibit a decided advance on those of the Wahsatch group, as they include a proboscidean (*Mastodon productus*, allied to *angustidens*), five carnivora (four of them dogs or wolves), and eleven Artiodactyla, giving a decided preponderance to the gyrencephalous forms. All these fossils are beautifully figured in the numerous plates, which, as we have already stated, accompany the volume, and place visibly before us the forms and characters of the magnificent series of remains of vertebrate animals which it has been the author's good fortune to work out and describe.

Of State Geological Survey Publications, we have received a volume of the "Geology of Wisconsin,"* which, although professing on its title page to be the second volume, is in reality the first issued. The first volume, we are told by the chief geologist, Mr. T. C. Chamberlin, will contain "general conclusions that can only be arrived at after the completion of field work, and its appearance must be delayed until that work is accomplished." The State of Wisconsin occupies a large extent of ground between the western shore of Lake Michigan and the Mississippi river, and the work before us includes the details of the topographical and geological structure of all but its north-western portion. It is divided into three sections: the first, relating to the eastern parts, is by the Chief Geologist himself; the second, describing the central regions, is by Mr. R. D. Irving; whilst Mr. Moses Strong gives an account of the lead region, a comparatively small district in

* "Geology of Wisconsin, Survey of 1873-1877." Vol. II. Accompanied by an Atlas of maps. Published under the direction of the Chief Geologist, by the Commissioners of Public Printing. 8vo., 1877.

the south-western corner of the State. All these gentlemen seem to have done their work in a most conscientious manner, and although probably many details still remain to be investigated, the result of their labours furnishes a very good idea of the geological phenomena of this region. Its structure, indeed, is tolerably simple. In the northern part of the State there is an immense mass of crystalline rocks, which are for the present referred to the Laurentian. These are partially overlain by quartzites, slates, &c., identified with the Huronian, and like it containing considerable quantities of iron ores; and both these archæan formations make their appearance now and then through the more recent rocks of the other parts of the state. Even these newer formations are all of very ancient date. In central Wisconsin no rocks are met with younger than the Lower Silurian Trenton and Galena limestones; whilst the eastern division contains the Cincinnati, Niagara, and Lower Helderberg groups, and also exhibits a small development of the Hamilton group of the Devonian. Above these Palæozoic rocks there is nothing except the Drift and the Champlain deposits. Mr. C. W. Wright appends to the second section descriptions of the microscopic characters of a great number of the crystalline rocks. Besides describing the geology of the country, each author furnishes details of the topographical character and hydrology, and of the soils and vegetation of the region surveyed by him, so that the physical geography of the country is pretty well worked out, and the whole is admirably illustrated by the magnificent atlas of 14 large coloured maps and sections which accompanies the volume. The book itself is also profusely illustrated with plates and woodcuts.

Not to be behindhand with its neighbour on the other side of the Mississippi, the State of Minnesota has also its survey, directed by Professor N. H. Winchell, which is placed under the care of the Board of Regents of the University of Minneapolis. It has the title of the Geological and Natural History Survey of Minnesota, and its fifth Annual Report* has just reached us. This includes reports on the geology and surface features of Houston and Hennepin counties, in which the phenomena presented by the drifts are especially dwelt upon, and the question of the time occupied in the recession of the Falls of St. Anthony, which was briefly referred to in our last number (p. 319), is treated in considerable detail. The botanist, Dr. A. E. Johnson, contributes a list of the known fungi of Minnesota, which is of interest to the student of the geographical distribution of those plants; and the Entomologist furnishes a long report on the evil-doings of that scourge of the American agriculturist, the Rocky Mountain locust. The other contributions are chiefly of local interest, except the description of a new species of *Cyclops* (*C. longicornis*) by Mr. C. L. Herrick. The illustrations consist of a few woodcuts and several maps, some of which are coloured.

The report of the United States Commission of Fish and Fisheries for 1875-76†, which has recently appeared, relates more specially than some

* "The Geological and Natural History Survey of Minnesota. The fifth annual report for the year 1876." 8vo. St. Paul, Pioneer Press Company, 1877.

† "U.S. Commission of Fish and Fisheries." Part IV. Report of the Commission for 1875-76. 8vo. Washington Government Printing Office, 1878.

former reports to the question of the falling off in the supply of food fishes and the means to be adopted for restoring it to a satisfactory condition; in an appendix exceedingly interesting details are given with respect to the vigorous attempts which have been, and are still being made, to restock the fresh waters of the United States with those valuable species of fishes, especially salmonidæ, which formerly swarmed in them, but have given way before the rapid increase of population. But the greater part (nearly 800 pages) of the stout octavo volume before us is occupied by a most elaborate report on the history of the American whale fishery, from its commencement, in the year 1600, to the present day, illustrated with six plates, giving outline figures of different species of whales and the instruments used in their capture, and accompanied by a tabular list of all the voyages that have been made by American whalers and their results. As a statistical record this will be found of the highest value.

URE'S DICTIONARY OF ARTS, MINES, AND MANUFACTURES: SUPPLEMENT.*

ON the completion of the third volume of this Dictionary, in 1873, it was found that several of the articles contained in the earlier portions of the work required amplification, in consequence of the rapid advances which had taken place in the various applications of science. In order, therefore, to bring up the information to the present date, as well as to record the general progress of mining and metallurgical invention, the present supplement has been written. In carrying out this work Mr. Hunt has secured the assistance of gentlemen practically acquainted with the various subjects on which they have written, and has also been furnished with information by various correspondents possessing special information upon the subject of arts, mines, and manufactures. Obligations are also freely acknowledged to such journals as the "Engineer," "Engineering," the "Chemical News," &c., as well as the "Transactions of the American Institute of Mining Engineering," the "Journal of the Franklin Institute," and the "Mining Journal of New York."

Among the more lengthy communications is a valuable article on the "Manufacture of Boots and Shoes by Machinery," by Mr. R. Meade; this extends over about thirty-five pages, and is illustrated by numerous woodcuts of the most modern machinery and appliances employed in that branch of manufacturing industry. From the statistics accompanying this article it appears that our largest customer for boots and shoes, of all kinds, is Australia, to which colony, in 1875, no less than 185,688 dozen pairs were exported; while the next largest amount, namely, 94,153 dozen pairs, was sent to British possessions in South Africa.

Mr. John Darlington contributes papers upon "Ore Dressing" and "Rock-boring Machinery," in which he has collected much valuable information upon a subject to which he has devoted considerable attention. Mr. G. A. Cowper's articles upon "Furnaces and Hot-blast Stoves" are sound and

* "Ure's Dictionary of Arts and Manufactures." By Robert Hunt, F.R.S., &c. Vol. IV.—Supplement. 8vo. London, Longmans, 1878.

practical; and the "Diamond Mines of South Africa" are well described by Mr. Francis Oats, who for some years occupied the position of Provincial Mining Engineer at Kimberley. Mr. Robert Oxland, of Plymouth, furnishes a description of his rotating calciner for sulphurous and arsenical ores; and Mr. Thomas Andrews, of Edinburgh, gives an article upon the "Mineral Oils used for Lighting Purposes."

The shorter notices have been carefully prepared, and supply information upon such recent discoveries as the telephone and phonograph. The Supplement to "Ure's Dictionary" is in every way worthy of the original work, and will form a valuable addition to the library of the miner, manufacturer, and metallurgist.

THE SIGHT.*

DR. ANGELL'S little book on "The Sight" is intended by its author to diffuse generally a knowledge of the phenomena of vision, and to furnish the public with reliable information as to the means to be adopted for the preservation of the faculty of sight. In face of the increasing prevalence of weak sight among us, it must be confessed that this object is a most important one, and we can only express a hope (not a very sanguine one, however) that it may satisfy the author's aspirations. If it fails, it will not be his fault, as his book is certainly one of the best adapted to its purpose that we have seen. The use of technical language is avoided as much as possible.

Dr. Angell furnishes his readers with a short description of the structure of the eye, so as to explain how we see, and what are the causes of defective vision. He then proceeds to the discussion of the various kinds of defective vision, their causes and remedies, or at all events the best modes of ameliorating those defects of vision which steal upon us in consequence of increasing years or failure of the eye at an earlier age. His remarks upon near sight in children and young people and its causes are of great importance.

There are one or two points to which we may refer.—At page 42 the author says that "twenty-five men in every hundred are more or less colour-blind: they cannot distinguish red from green." This ratio is much higher than is generally admitted, though perhaps very slight degrees of colour-blindness may occur in such proportions. On page 29, line 22, the eye in near sight is said to be "adjusted or accommodated" for a point nearer than the object looked at; the use of these two terms is unfortunate, as they are technically used to signify the change in the refractive state of the eye brought about by muscular action. The refractive state of the eyeball in near sight is dependent on the construction of its media, and would continue in a dead eye if this preserved its shape and clearness. The true sense of accommodation is given by the author at page 12, but it might easily escape the memory of a reader interested only in near sight. These and one or two other small matters which might be cavilled at are, however, of little consequence, and we may recommend Dr. Angell's book as a very clear and comprehensive treatise on the management of the eyes. It is freely illustrated.

* "The Sight and How to Preserve It."—By Henry C. Angell, M.D., Professor of Ophthalmology at Boston University, sm. 8vo., London: Hardwicke and Bogue, 1878.

TELEGRAPHY.*

THIS is essentially a working book, and its value in this capacity may be appreciated from the fact that it is now in its seventh edition.

The telegraphs in Great Britain and Ireland having now passed into the hands of the State, a sketch of the history of the system is given by way of introduction.

This notes the joint patents of Cooke and Wheatstone in 1837, which first demonstrated the practicability of the plan on an experimental circuit between Euston and Camden Town, followed in the next year by an actual working telegraph between Paddington and West Drayton. These patents were purchased by the Electric and International Company, incorporated by Act of Parliament in 1846, but for several years proved to be pecuniarily unprofitable.

At first the double needle was used for the more important circuits, the single for the less important.

The former was superseded by Bain's chemical recorder, and this in turn gave way to Morse's ink-writer, the single needle holding its place in consequence of the ease with which it is kept in order.

The magnetic instrument was found to be laborious in manipulation. Bright's bell instrument leaves the hands free for writing the message. The United Kingdom Company used the Morse and Hughes's systems only.

The first six chapters, occupying 113 pages, are devoted to the laws of electricity generally; the seventh and eighth, amounting to 132 pages, explain construction and modes of testing. Part IX. is concerned with apparatus, relays, duplex working and Hughes's instrument; Part. X. with submarine telegraphy; Part XI. with automatic telegraphs which record their signals; the twelfth and last section with recent inventions, the telephone and the quadruplex system.

Valuable tables of logarithms, measures, constants, guages and coefficients conclude a very practical work. The text is illustrated with abundant figures and diagrams; and simple numerical examples are introduced freely wherever they are needed.

W. H. Stone.

PHOTOGRAPHY.†

ANYTHING Captain Abney may publish on the subject of Photography is sure to be of value. The present work is stated to be supplemented by that on "Instruction in Photography," by the same author; it having been found impossible to compress the necessary matter into a single volume.

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* "A Handbook of Practical Telegraphy," by R. S. Culley. Seventh Edition, revised and enlarged. London: 8vo. pp. 468. Longmans, 1878.

† "A Treatise on Photography," by W. De Wiveleslie Abney, Captain R.E., F.R.S., &c.: sm. 8vo. pp. 326, London: Longmans, 1878. Text-books of Science.

Hence this is devoted less to what may be called commercial applications of the art, and more to the theoretical aspect of the subject.

It commences with a historical sketch of the early experiments of Wedgwood, Niepcé, Daguerre, and Talbot, occupying five pages, followed by four pages of experiments on Light. These bear traces of haste, due probably to the necessity for great condensation. For instance, silver chloride is described as luna cornua, light as a *fluid*, and parallel rays in the dark chamber are made, by the illustration on page 7, to pass with unaltered parallelism through a condensing lens and a prism, and still uninverted, to give a real image on a screen.

With Chapter III., containing the theory of sensitive compounds, we reach more congenial ground, and in the 36 chapters which follow, it is remarkable how much practical information has been condensed into a little over three hundred pages. Indeed it is not possible with limited space to do more than enumerate the chief topics introduced. Sensitive silver, iron, and chromium salts; asphaltum, dyes, chlorine and hydrogen, sulphur and antimoniuretted hydrogen as influenced by light, form the bulk of the fourth; the daguerreotype, collodion, the wet process, development, intensifying and fixing, each furnishing successive chapters. An account of wet-plate manipulation, and its defects, both in negative and positive pictures, is followed by dry plate, gum, gallic, and albumen-beer processes. Emulsion processes, the gelatino-bromide and calotype processes, are each separately described. Silver printing and its manipulation is adverted to at some length; as is printing with iron, uranium and chromium salts. Photo-lithography, photo-engraving and photo-collotype bring to an end the list of methods. The twenty-ninth section describes the lens, and the thirtieth the camera, tents, dark rooms, and other apparatus. It may be noted here that perhaps the laws of refraction, dispersion, aberration, conjugate foci, and some other common places of optics, in a case where space is evidently precious, might well have been left to rudimentary text-books on that subject. Chapter thirty-one on the picture, the choice of a point of view, grouping, and composition, is of remarkable value, illustrated as it is by some charming little woodcuts. A stranded boat by Manners Gordon, and a view on the Thames by Woodbury, positively light up their respective pages. There is a return, in the three following chapters, on actinometry, photo-spectroscopy, and thermal photography to purely theoretical considerations; and in those on solar, stellar, and celestial work we have a good *résumé* of the astronomical value of this fascinating art. Micro-photography, and some miscellaneous applications, such as that to meteorological registration, to military service, and to the identification of criminals, conclude the work.

In another edition, the feeble woodcut of temporary photo-spectrum apparatus at page 265, the description and drawings of Mr. Browning's automatic arrangement, and of Stoney's Heliostat, might well be omitted in favour of more specifically photographic apparatus. But there is much valuable material in the book.

W. H. Stone.

SPECTRUM ANALYSIS.*

THE demand for a reprint of this work within a few months of its first issue is, of itself, evidence of the interest which it has deservedly excited. Nor is there any difficulty in explaining the fact, since it distinctly occupies a gap, and fills up a lacuna left by such excellent treatises as those of Roscoe and Schellen. It does not even clash with the same author's other volume on working with the Spectroscope, published by Macmillan. The discovery of spectrum analysis has indeed opened such a vast and new field to human observation, that there is abundant room, nay, imperative necessity, for manuals and treatises of very diverse nature. This is well described in its opening sentence: "The work of the true man of science," says the author, "is a perpetual striving after a better and closer knowledge of the planet on which his lot is cast, and of the Universe in the vastness of which that planet is lost. The only way of doing this effectually, is to proceed as gradually, and therefore as surely, as possible, along the dim untrodden ground lying beyond the known."

Whereas former works have been dogmatic, descriptive, and educational, this rather aims at being tentative, inductive, and experimental.

As the whole subject is to many readers new and unfamiliar, the first forty-six pages have been devoted to a *précis* of the great generalization of waves and wave motion on which modern physics rests. These we may be excused for passing over in a brief notice like the present. The second chapter deals with modes of demonstration and laboratory work. Here we at once find matter of specific interest.

Attention is called to the difference between the ordinary spectroscope and one that has a lens before the slit. If light be allowed to enter indiscriminately as it emanates from a complex source, in each part of the spectrum we get an "integration" of the light of the same wave-length proceeding from all the different light-waves. But if by means of a lens we form an image of the source, so that each particular part shall be impressed in its proper place on the slit, then in the spectrum the different kinds of light will be sorted out, and if there be any variety in the phenomena which these different sources of light present, they will be all clearly shown in the spectrum or its photograph. We turn the spectroscope from an "Integrator" into an "Analyser." The slit for a vertical image of a candle, for instance, requires to be placed horizontally. We then get three perfectly distinct spectra indicating the coexistence of three light sources, each with its proper spectrum, in the light of a common candle.

This mode of observation, originally proposed in 1866 by the author, for the examination of minute portions of the Sun and his surrounding atmosphere, has been adopted in most of the work subsequently detailed. In a photograph of a *horizontal* electric arc, thrown by means of a lens on a vertical slit, it is shown that the spectrum consists of a large number of lines of different lengths in the "core" or centre of the arc, all of which die

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* "Studies on Spectrum Analysis." By J. Norman Lockyer, F.R.S. Cr. 8vo. pp. 258. Kegan Paul & Co. International Scientific Series. Second

out gradually, until that of the part farthest from the centre consists of one line.

In thus employing sodium, bright lines are obtained of different lengths, without any continuous spectrum; and as the distance between the poles is increased, one line is seen alone and much brighter than the rest, the yellow line remaining after the others have disappeared. "The spectroscope, thus armed, is in fact a new instrument."

Radiation and absorption phenomena are next described, and some charming modes of demonstration, which space alone excludes here, are described.

The third chapter deals with spectrum photography. Its history is given in Mr. Lockyer's brilliant style, and will well repay reading, especially his quaint description of Mr. Rutherford's telescope "through which it is impossible to see anything, but through which the minutest star can be photographed with the most perfect sharpness."

He then describes his own arrangements, especially that of the fivefold slit, and the various means of comparing spectra. Here, as in the frontispiece, and in four other cases, we find a striking whole page illustration, the reproduction of a photograph, the method of obtaining which does not appear to be given, but which seems to be lithographed in a grey pigment on black paper.

Chapter IV. considers Atoms and Molecules spectroscopically. After a recapitulation of modern views as to the molecular condition of matter, twenty-one propositions are in turn discussed, many of which are of the highest importance. A few of these may be noted: (5.) The spectra of both elementary and compound bodies vary with varying degrees of heat. (7.) There is spectroscopic evidence that matter is continually broken up as the temperature rises. Five stages of this process are given: α. Line spectra. β. Fluted spectra. γ. Continuous absorption at the blue end. δ. The same at the red end. ϵ. "Unique" (Complete?) continuous absorption. (12.) Particles absorb light of the same wave-length, and greater amplitude. (20.) Some vibrations are very closely connected with others, as evidenced by repetition of similar groups of lines in different parts of the spectrum. For example,—in sodium the longest line, D, is double. So are all the lines. In magnesium the longest line is triple. So is that in the violet. Long and short lines are treated next, and the spectra of salts follow. In the section on dissociation, the chemist, in the separation of elementary bodies, is shown to act mainly by means of vibrations. "He finds the world composed of molecules in millionfold complexity, combination, and size, and he acts upon these molecules by vibrations. For gross molecules he finds in heat most that he wants; but when the molecules are more delicate, then electricity is called in." With the aid of the spectroscope, additional help is afforded in the study, both of the quantity and quality of dissociation, and it is found to afford precious suggestions regarding change of molecular structure. The conclusions come to are: (1.) That a compound body has as definite a spectrum as a simple one; but while the spectrum of the simple metal consists of lines, the number and thickness of some of which increase with molecular approach, the spectrum of the compound consists in the main of channelled spaces and bands, which increase in like manner. Both spectra have their long and short lines. (2.) That the heat required to act on a compound so as to

render it visible, dissociates the compound according to its volatility; the number of true metallic lines which thus appear is a measure of the dissociation; and as the metal lines increase in number the compound bands thin out. This principle is applied to the dissociation of the so-called elements, especially calcium. Evidence in favour of this is derived first from a series of five spectra of this substance at different temperatures, and secondly, from the remarkable photograph of the spectrum of *a* Lyræ obtained by Mr. Huggins, in which only *one* of the solar H lines is represented.

If the elements be really compounds, these must have been formed at very high temperature, to which, by theory, there is no superior limit. If calcium be a distinct entity, by working at it alone, we shall never know "whether temperature produces a simpler form of the same thing, or whether we actually break it up into X + Y, because neither X nor Y will ever vary. If it be a product of lower temperature, then in stars hot enough to enable its constituents to exist uncompounded, we may expect them to vary in quantity, and *a* Lyræ would thus represent an extreme case."

An attempt at Quantitative Analysis by means of the spectrum is the next topic introduced, an idea first suggested by Janssen, and demonstrated by Frankland, who showed that the spectrum of hydrogen at a pressure of 20 atmospheres is as continuous as that from burning coal. In the solar spectrum the line in the green widens toward the Sun, indicating an approximation to a continuous spectrum; at 20 atmospheres it would be continuous. Increase of pressure is therefore the determining power. If so, the same lines should become thinner with decreased pressure, and thicken with its increase. This they do. There is, therefore, "individuality" in the spectral lines. Experiments by mixture were made to carry out this idea. Alloys of silver and gold obtained from the Royal Mint were also employed for the purpose, the results being represented by curves, the co-ordinates of which showed the composition of the alloys as determined by the ordinary method of assay, compared with the varying points of equal brightness measured by the micrometer of the observing telescope fitted with movable horizontal wires. The parting assay determination, when revised, was almost identical with that of the spectroscope.

A chapter on coincidences of spectral lines, and the elimination of those due to impurities, leads to the tenth and last on the elements present in the Sun. Kirchhoff and Angström's work is reviewed; it is shown that when the spectra of metallic vapours reversed in the solar spectrum are mapped by the new method, the reversed lines are invariably those which are longest in the spectrum. It was thus at once seen that zinc, aluminium, and, possibly, strontium must be added to the table of solar elements.

As a preliminary, two lists were formed, one containing solar, the other, non-solar elements. The former were found, as a rule, to form stable oxygen compounds, and others of this group were then sought for. Cadmium, lead, copper, cerium, and uranium were provisionally added to Thalén's last list.

As the final result of laborious work, three tables are given: the first, of elements whose presence in the Sun's reversing layer has been confirmed, amounting to 22; the second, of those whose presence is probable, in number 10; and the third, of elements absent from the Sun, according to our present knowledge. These are carbon, silicium, and thallium, chlorine, bromine.

FUNGI.*

It is impossible to express too strongly the obligations under which students of natural history lie to those of their number who will undertake the labour of bringing together, into one handy book, references to all the scattered descriptions and figures published upon some group of animals or plants. This indebtedness is very great even when the compilers limit themselves to the preparation of a mere catalogue; but when, as in the case of Messrs. Cooke & Quelet's "Key to the European Hymenomycetous Fungi," brief characters of the species are added and the whole mass of information is condensed into a volume small enough to be conveniently carried in the pocket, it must be confessed that the authors have conferred upon their brother naturalists a boon of the very highest value. The "Clavis Hymenomycetum Europæorum," which is written throughout in Latin, contains short characters of nearly 2,000 species of agarics, boleti, and their allies, and will stand the travelling mycologist in good stead in the determination of unknown plants of this important order that he may meet with. The reputation of the writers is a sufficient guarantee of the quality of their work.

MILLER'S ELEMENTS OF CHEMISTRY. SEVENTH EDITION.†

MILLER'S "Elements of Chemistry" has long held a distinguished position among chemical text-books, and there can be no doubt that the present edition, which has been ably edited by Mr. Greene, who has contributed much additional matter, will be equally appreciated by chemical students.

Commencing with elements which form the most simple compounds, and gradually passing onwards to those forming more numerous and complicated substances, the order in which the non-metallic elements and their compounds are described is the same in this edition as in the last. As a standard of reference for the atomic weights of the elements and the densities of gases, as well as for a measure of the affinity of the other elements, hydrogen occupies the first place, as being the type of electro-positive substances. This is followed by chlorine, as an example of an electro-negative element of remarkable chemical activity, and which forms a large and important series of combinations. Oxygen is then brought before the attention of the student as one of the most important elements, and one which on that account is even now sometimes placed first in order, as was the case in the earlier editions of this work. The compounds of oxygen with hydrogen and chlorine are subsequently described: then follow boron, a triad; carbon, a tetrad; nitrogen, a pentad; sulphur, a hexad; together with the compounds they severally produce with the elements previously studied. The other non-

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* "Clavis Synoptica Hymenomycetum Europæorum, auctoribus eximiis scriptoribus M. C. Cooke, M.A., F.L.S., et L. Quelet, M.D., Soc. Mic. et Sorb. Lear." 8vo. pp. . London, Hardwicke & Bogue. 1878.

† "Elements of Chemistry: Theoretical and Practical." By William Allen Miller, M.D., LL.D., late Professor of Chemistry in King's College, London. Revised by Charles E. Groves, Fellow of the Chemical Societies of London, Paris, and Berlin, &c. Part II. Inorganic Chemistry. Seventh Edition, with Additions. 8vo. London, Longmans, 1878.

metals are described in an order consistent with the arrangement of the more typical elements.

The formulæ used are substantially those employed in the last edition, and wherever the constitutional formulæ suggested by Dr. Frankland are introduced, they are enclosed within square brackets to indicate that they are an interpolation in the original work. The whole bears evidence of careful revision, and many additions, particularly in the portions devoted to the non-metallic elements, have been made. The metallurgy of all the more important metals is described with sufficient detail to afford general ideas of the various processes employed; but in the case of iron, the production of which gives rise to one of our most important technical industries, its metallurgy is given with considerable detail. Sections are introduced on the recently discovered metals, gallium and davyum; a copious index has been supplied, and every care appears to have been taken, not only to insure great accuracy, but also to render the information furnished readily available.

This work can be equally recommended to the beginner and to the advanced student of chemistry, since whilst it leads the former over a judiciously traced route to an acquaintance with that science, it at the same time affords the latter a well-arranged and reliable book of reference.

SCIENTIFIC SUMMARY.

ASTRONOMY.

The Eclipse of July 29.—Undoubtedly the observations made during the recent eclipse form the chief feature of the astronomy of the last quarter. It was thought by many that little of importance would be learned. We are told, indeed, that one distinguished American astronomer declined to visit the shadow-track, on the ground that eclipses were "played out." But the observations were, in reality, of extreme interest and importance.

In the first place the extension of the corona outwards into the zodiacal light has at last been demonstrated. Few who have studied eclipse phenomena carefully have doubted that the outer corona belongs to the core of the zodiacal light, but this could not be said to be demonstrated observationally until the zodiacal light had actually been seen during total eclipses. Hitherto observers had failed to effect this. During the eclipse of December, 1870, Professor Newcomb employed the method suggested by Mr. Proctor a few months earlier, concealing the lighter part of the corona, and thus enabling the eye to search more effectually for the fainter light of the zodiacal.

But he failed on that occasion, the air being hazy at his station, and the circumstances otherwise unfavourable for an observation of so delicate a nature. Last July he repeated the attempt, and was rewarded with complete success. Stationed high above the sea level, and observing through an atmosphere of the utmost purity, he was able to trace a faint luminosity outside the corona proper, to a distance of six degrees from the eclipsed sun, nearly in the direction of the ecliptic. Professor Langley, on the summit of Pike's Peak, 14,200 feet above the sea level, saw the corona elongated in the same direction as the ecliptic. He says: "It resembled the zodiacal light; I followed it in the most transparent atmosphere to a distance of twelve diameters of the sun on one side, and three on the other." Professor Cleveland Abbe, who was to have observed the eclipse from the same station, was taken ill the day before, and had to be removed to the Lake House (hotel), 10,000 feet above the sea level. He had no instruments. But having recovered sufficiently by Monday afternoon to be carried out to a slope facing westward, he then observed the corona with the naked eye during the whole of totality. He did not notice the faint luminosity, extending to a distance of twelve solar diameters, which Newcomb and Langley saw, but he obtained a more satisfactory view of coronal details (may we not almost say zodiacal details?) to a distance of about six diameters. In the direction of the

ecliptic he saw a long pointed ray on the east of the sun, extending to this distance, while on the west of the sun, and as if forming a prolongation of the pointed ray, was a fan-shaped ray only about half as long. At right angles to these long rays were two others forming a similar system, the uppermost was pointed, and extended to a distance of about five diameters, the lowest was fan-shaped, and extended to a distance of about one and a half diameters. Professor Abbe considers that these were meteor systems—"not such meteors as some suppose to be falling into the sun daily, but the grand streams of meteors that cause the numerous shooting stars of August and November, and of the existence of which there is indubitable proof." In this form his explanation is certainly untenable, for the position of the August and November meteor systems is known, and they could not possibly have presented the appearance observed by Abbe. Nor, indeed, is it possible that these systems could be visible during total eclipse, for they are too sparse and too far from the sun. Whether other meteor systems much denser, and more fully illuminated because nearer to the sun, can explain the appearances seen by Professor Abbe, is a question not to be quite so readily answered. But the probabilities seem enormously against the theory that separate meteor systems produced the observed phenomena. Probably the radial extension of the light is to be explained in the same way as the extension of comets' tails in the direction from the sun. But as yet this phenomenon has not been explained satisfactorily.

The theory that the outer regions of the corona, and especially the long rays, are either merely subjective phenomena, or phenomena of our own atmosphere, has been finally overthrown by the eclipse observations.

The Corona during the late Eclipse.—It was generally agreed that the inner corona was much less extensive than during the eclipses of 1870, 1871, but that it was very bright to a height of 5′. In some accounts it has been stated that the spectrum of the corona did not show the green line 1474 Kirchhoff. But Professor Eastman traced it on all sides to a distance of two-fifths of the sun's diameter from the moon's edge. Mr. Thomas, and other observers, also saw this line. It seems clear, however, that the gaseous matter to which this line is due did not extend nearly so far from the sun as on former occasions.

Photographing the Corona's spectrum.—It has been asserted that the spectrum of the corona was photographed on this occasion in such a way as to show that those (including Captain Noble, and Messrs. Proctor, Ranyard, and Brothers) who predicted, in 1875, the failure of the methods proposed for photographing the corona, were altogether mistaken. This, however, is remote from the truth. In 1875 a method was proposed, which involved, among other objectionable features, the use of a prism in front of the object glass. And what was then aimed at (what, in fact, was promised by those who planned the operations), was that separate views of the corona by the green light corresponding to 1474 Kirchhoff, and by the light corresponding to the hydrogen lines, would be obtained for comparison with photographs of the corona by the whole of its light. In other words, we were told that by this method it would be possible to show how far the hydrogen constituent and how far the constituent corresponding to the line 1474 Kirchhoff, to the corona as seen by the naked eye, or as photographed. It

was this that the objectors said could not be achieved by the plan then proposed. If new plans had succeeded, during the recent eclipse, in achieving that very result the objectors would not have stood corrected. By the use of the Rutherfurd grating the chance of success was unquestionably greater than it had been in 1875. Moreover, terrestrial conditions during the recent eclipse were altogether more favourable than those of the eclipse to which their remarks related. But in reality, notwithstanding the greatly increased chances of success, and a marked improvement in the method of attack, the attack has failed as completely on this occasion as it failed in 1875. The spectrum of the corona has indeed been photographed. No one ever said that this could not be done, or even that it involved any difficulty. The spectral images of the corona, however, were not shown, even near the sun, where we know (from the observations of Eastman, Thomas, and others) that they undoubtedly existed. Dr. Draper, Professor Thorpe, and Mr. Lockyer all photographed the spectrum of the corona; but as Mr. Lockyer says, who certainly was not disposed to minimize their success, "we had photographed as continuous a spectrum as if a platinum wire or ball in a state of incandescence had been in front of our instrument, instead of a shell of hydrogen gas 6′ high as in 1869, 10′ high as in 1871." In other words, the method entirely failed to do what it had been expected to do, and what in 1875 Mr. Lockyer and others had promised for it. We do not doubt that the circumstances were in reality far less favourable than they had been in 1869, 1870, and 1871. For the 1474 line was very faint, F alone of the hydrogen lines could be seen, and no observer saw the spectral *images* (as distinguished from the spectral *lines*) of the corona at all. But to describe the failure of the method, however brought about, as involving the disproof of objections formerly urged against it, is absurd in the extreme. The objectors said the method would certainly fail in 1875, and it did then fail entirely. They were doubtful whether the improved method devised for the late eclipse would succeed, and it has not succeeded. Hereafter, under more favourable conditions, and with improvements in photographic appliances, a method may be devised for obtaining photographs of the spectral images of the corona; but that certainly has not been done yet, nor if it had been done would it have shown that the objections urged in 1875 were invalid. The validity of these objections was, in fact, demonstrated effectually and definitely by the results obtained during the eclipse of that year.

Polarization of the Corona.—The majority of the observations showed that the corona was polarized radially. But Professor Hastings believes that he obtained satisfactory evidence of tangential polarization. He explains what he saw by the theory that there are ice-crystals in the corona—which, to say the least, seems unlikely.

Heat of the Corona.—By means of his wonderfully delicate heat-measuring instrument, the tasimeter, Mr. Edison succeeded in proving that the corona emits or reflects an appreciable amount of heat. He was not able to measure the heat of the corona, however, in this way, simply because the instrument proved to be too delicate. The indicator went quite off the field of view, and before it could be brought back totality was over.

Intra-Mercurial Planet.—Professor Watson and Mr. Swift both recognized a star of the 4th magnitude, or rather less, close to Theta Cancri. Watson found that it had a recognizable disc with a magnifying power

If it was not the bright nucleus of a comet it must have been a planet. It appears, from calculations made by Gaillot, director of the Bureau des Calculs, that the observed place of the stranger agrees fairly with one of the orbits assigned by Leverrier to Lescarbault's Vulcan. If it should turn out that the stranger really is Vulcan, this planet travels round the sun in a period less than that in which the sun rotates on his axis. Its period is about 24½ days, its synodical period about 26 days, its mean distance from the sun about 15,000,000 miles. Professor Watson remarks that in superior conjunction the star may appear of the first magnitude. But if he could detect no departure from the circular form (and he writes "there was no appearance of elongation such as might be expected if it were a comet") the planet could not have been far from superior conjunction. Yet Gaillot says "that if the new body were Vulcan, only a very small part of the disc would have been illuminated." The inference seems to be that either Gaillot's theory of the new body must be erroneous, or else Watson's failure to recognize any departure from circularity was inexact to a very remarkable degree. On the whole, while the existence of an unknown body close to the sun on July 29 last seems very clearly made out, the identity of this body and Lescarbault's Vulcan seems very far from being established.

Magnetic and Electric Action in the Sun's Atmosphere.—M. Cornu, from an investigation of his spectroscopic observations, has arrived at the conclusion that the dark lines in the solar spectrum indicate the action of an absorbing atmosphere similar in its constitution to volatilized meteorites. From this he infers that the enormous mass of the sun's atmosphere, containing, like the meteorites, a large proportion of the vapour of iron, exercises an appreciable action on terrestrial magnetic phenomena, so that the diurnal variations of the needle would on this view be due to the direct magnetic action of the sun. He argues that, although iron when heated to incandescence loses its attraction on the magnet, it has not been proved that the attractive force is reduced rigorously to zero, and there may be sufficient left to exercise a very appreciable action on the earth. M. Cornu also considers that the earth, having probably a common origin with the sun, may also be largely composed of iron—a supposition which would explain terrestrial magnetism. Considering that the solar prominences show a spectrum identical, in the relative brightness and sharpness of the lines, with that of highly rarefied hydrogen rendered incandescent by the electric discharge, M. Cornu thinks it probable that, appearing as they do in the neighbourhood of faculæ and spots, they represent masses of gas traversed by induction currents in the neighbourhood of magnetic or electric regions in rapid motion, and that, as M. Fizeau has already pointed out, they are analogous to the terrestrial aurora. The prominences being, on this view, simply due to the illumination by induction currents of masses of rarefied gas, their rapid extension and sudden disappearance would be explained without having recourse to the hypothesis of jets of gas having velocities of hundreds of miles in a second.

Planetary Phenomena for the Quarter.—Neptune will be in opposition to the sun on October 31, at 10 P.M. Venus will be in superior conjunction with the sun on December 5, 6 P.M. Mercury will be in superior conjunc-

ber 24, at 8 P.M., and at its greatest easterly elongation (20¾°)

3, at 4 P.M.

BOTANY.

Insectivorous Plants.—M. Hochstetter argues in opposition to the opinion put forward by Darwin and adopted by many naturalists, that the insects captured by various plants serve them as nourishment. ("Württemb. naturwiss. Jahreshefte," 1878, p. 106.) He divides insecticidal plants into three categories:—1, Those which emit a tenacious fluid from various parts to which insects stick; 2, those which possess special organs (pitchers, &c.), into which insects make their way, and are either drowned in a fluid contained in the cavity or prevented from escaping by hairs or other mechanical means; and, 3, those which capture insects by means of irritable leaves or glandular hairs.

The first group, which is very numerous, has never been supposed to derive any benefit from the captured insects. This is not the case with the second, including the pitcher plants, &c., for the insects drowned in the fluid contained in the cavities presented by their peculiar organs are believed to aid in the nutrition of the plants. M. Hochstetter says that, so far as he knows, nothing has been ascertained in support of this opinion; [but it has been shown that the fluid from those pitchers exerts a digestive action upon animal substances, and contains a principle related to pepsine, although, we believe, no one has attempted to show how the products of such digestion may be absorbed by the walls of the cavity]. M. Hochstetter says that his observations on *Nepenthes*, *Sarracenia*, and *Cephalotus* show most clearly that the pitchers of those plants which contain many dead insects die off much sooner than those in which none or few are to be found.

It is in the third group that the most striking instances of supposed insectivorous plants are to be found. Of these it has been affirmed that, after insects are captured, the plants excrete an acid fluid at the points where they are in contact with their victims; that this is allied to propionic acid and even contains pepsine; and that by means of it the soft parts of the insects are digested just as if they were in the stomach of an animal.

The author notices the peculiarities of the three genera, *Drosera*, *Drosophyllum*, and *Dionæa*, upon which most of the observations in this direction have been made, and, whilst giving all credit to Mr. Darwin for his valuable investigations upon this interesting subject, urges certain objections against the view that the plants are nourished by the insects they capture. His first objection, that the leaves of plants are not organs for the reception of nourishment, does not appear to be of much weight. In the second place, he remarks that the insects captured by the leaves either dry up or putrefy; and in the latter case, according to his observations, they do not produce better vegetation, but the destruction of the leaf-tissue implicated, as he has frequently noticed both in *Dionæa* and *Nepenthes*. In *Drosera*, however, stronger growth of the neighbouring parts of the leaf, sometimes perhaps of the whole leaf, does occasionally take place. But, says M. Hochstetter, we know that whenever vegetable tissues are exposed to friction, and especially when leaves are pierced by insects, or eggs are laid in their cellular tissue, cellular growths occur; and he indicates that in *Drosera*, vesicular inflations are produced on the leaves at the points where the insects lie.

The fact that an increased secretion of fluid takes place from the glands of

the leaves, and that the contents of these glands are altered, which has been regarded as evidence of the digestion of the captured insects, is regarded by M. Hochstetter rather as a sign of injurious action, such as is produced by acids and gases noxious to the life of the plant. He refers to the injurious action of ammonia upon plants placed in a fresh hotbed with the frames closed; and considers the saccharine excretion of leaves attacked by aphides to be a morbid phenomenon analogous to the increase of the fluid excretions in the plants in question. Thirdly, he remarks that *Dionæa* cultivated under bell-glasses are much stronger and more healthy than those grown in the open and allowed to catch flies. From all this M. Hochstetter concludes that the necessity or even the usefulness of the digestion of insects by plants is still far from being incontestably proved.

Milk of the Cow-tree.—M. Boussingault, when at Maracay, in South America, made a rough examination of the milky fluids furnished by this celebrated tree (*Brosimum galactodendron*), which is widely distributed in tropical America. He obtained from it—

1. A fatty substance like bee's-wax, fusible at 50° C., partially saponifiable, very soluble in ether, but slightly soluble in boiling alcohol. This substance when melted and cooled resembled virgin wax, and candles were made of it.

2. An azotized substance analogous to caseum.

3. Saccharine matters.

4. Salts of potash, lime, magnesia, phosphates. The quantity of solid matter in the milk was estimated at 42 per cent.

Samples of this milky juice sent to the Paris Exhibition of the present year, gave a dried extract, 100 parts of which furnished—

Wax, fatty matter	84·10
Sugar, inverted	2·00
Sugar, inversible	1·40
Gum, saccharifiable	3·15
Caseum, albumen	4·00
Ash, phosphates	1·10
Undetermined non-nitrogenous substances	4·25
	100·00

Which, brought to milky juice containing 42 per cent. of solid matter, gives—

Wax and saponifiable matters	35·2	
Saccharine and analogous substances	2·8	
Caseum, albumen	1·7	4·0
Earths, alkalies, phosphates	0·5	
Undetermined substances	1·8	
Water	58·0	
	100·0	

Thus in its general constitution, the milk of the cow-tree approaches cow's milk, except that it contains about three times as much solid matter; so that it is rather to cream that we must compare this vegetable milk. A cream analy er gave—

Butter	34·3
Sugar of milk	4·0
Caseum and phosphates	3·5
Water	58·2
	100·00

The butter here is nearly in the same proportion as the waxy matter in the milk of *Brosimum galactodendron*; and as fatty matters susceptible of being split into acids and glycerine are assimilable, it is easy to understand the nutritive properties of the latter.—*Comptes rendus*, August 12, 1878.

CHEMISTRY.

Atmospheric Hydrogen Peroxide.—There has recently appeared in the "Berichte der deut. chem. Gesellschaft" a very exhaustive report by Em. Schöne of Moscow on the amount of peroxide of hydrogen present in air and in atmospheric deposits. It is divided into four parts (see vol. xi. pp. 482, 561, 874, and 1028), and gives the details of a lengthy investigation, extending from July 1, 1874 to June 30, 1875; it is one which has evidently been conducted with wonderful patience and care. During the year he examined 215 specimens of rain and hail, and snow and sleet were tested on 172 occasions, making altogether 387 specimens submitted to examination. Seven samples of rain and 86 of snow appeared to contain no peroxide, or so small a quantity that it was left open to doubt and was recorded as O. The deposits brought by the equatorial currents always contained more peroxide than those falling at times when the polar current opposed them; and when the polar stream of air predominates the relatively smallest yield of peroxide is obtained. The amount attained a minimum in December and January, very slowly increased till April, was very much higher during May and June on to July, when it culminated. During the next three months it fell rapidly, and in November again very slowly approached the minimum. The hail of summer contained a comparatively large amount of the peroxide, although it is less abundant in hail than in rain; and the winter rain yields more of this compound than snow falling at the same period. The total amount of hydrogen peroxide which reached the earth's surface during the year is computed by the author to have amounted to 109·4 milligrammes to the square metre, that is to say in 599·9 litres of water, or 1·049 kilog. to the hectare. The peroxide present in the air in a state of vapour was collected and determined by producing artificial dew with the aid of freezing mixtures, and it was found that the rise and fall in the amount so obtained corresponded and went hand in hand with the numbers obtained by testing the atmospheric deposits. The diurnal variation was studied, and it was ascertained that the maximum amount was present at about four o'clock in the afternoon, after which it diminished, the minimum being attained between midnight and 4 A.M. The air of a large hall, which had been unoccupied for four weeks and the windows of which were closed but were not air-tight, was observed to contain an average of

0·17 c.c. peroxide in 1,000 cubic metres. In dew artificially deposited in a badly ventilated room there was no peroxide; its presence, however, became manifest as soon as the windows were thrown open. Dew and hoar frost deposited during the last hours of the night appeared to be pure water; in dew collected during the evening hours peroxide was met with, the amount being 0·05 gramme to the litre. The peroxide is present in fog, and is apparently more abundant in spring than in autumn. The amount of peroxide present in any atmospheric deposit varies with the altitude at which that deposit has been formed; the greater the altitude at which the condensation takes place, the greater is the quantity of peroxide which it will contain. This is doubtless due to the decomposition which that substance must undergo when exposed to organic vapours rising from the earth's surface. In the air itself there is but little peroxide, the maximum quantity observed being 1·4 c.c. in 1,000 cubic metres of air. The author points out the scientific advantages which would attend systematic observation in this field at our meteorological stations.

Cast Manganese.—Jordan has presented to the Academy of Sciences of Paris a specimen of fused manganese, obtained by smelting manganese ores in the blast furnace. About 10 per cent. of the metal is lost during the operation, and it seems not improbable that the metal is volatile at higher temperatures. The manganese appears to be very stable, the specimen above referred to having undergone no perceptible change in six months. It consists of

Manganese	84·960
Iron	8·550
Carbon	5·700
Silicium	0·660
Sulphur	0·035
Phosphorus	0·005
	99·910

In one specimen the percentage amounted to 87·4.—*Compt. rend.* 1878, No. 22.

Expansion of Bismuth.—Marx directs attention to an experiment which admirably illustrates the force with which a metal like bismuth expands during the act of solidifying. He dips a long and narrow glass tube into the melted metal, and sucks it up the tube to a height of eight or ten inches. On allowing it to cool, the tube is shattered, often with explosive violence. The tube cracks along its length, and is broken up into long parallel glass rods or threads, which it would be difficult to produce by any other means.—*Pol. Notizblatt*, xxxiii. 44.

Absorption of Carbonic Oxide by the Blood.—Gréhart's experiments on this subject have led him to the conclusion that if a man or animal be placed for half an hour in an atmosphere containing 1-779th of carbonic oxide, one half of the red corpuscles will have taken up sufficient of the gas to render them unable to absorb oxygen; by exposure to an atmosphere containing 1-1449th of carbonic oxide, about one-fourth of the red corpuscles are rendered inactive.—*Compt. rend.*, 1878, lxxxvi. 895.

Alum and Dysentery.—Dounon's observations go to show that dysentery

caused by the introduction of *Anguillula stercoralis* and *dysenterica*, *Ankylostoma dysenterica*, &c. into the intestinal canal by means of polluted water, may be avoided by dissolving alum in the water, although this is, of course, a less desirable method than that of boiling the water. The treatment with alum has, it is said, been successfully used by the natives of Annam from early times; while for several years it has completely protected the French troops in Cochin China from this dreadful scourge.—*The Chemical News*, 1878, xxxviii. 24.

An interesting *résumé* of the present state of our knowledge of the synthetical processes which are in operation in the bodies of animals has just been published by E. Baumann. It is entitled: "Ueber die synthetischen Processe im Thierkörper" (Berlin: Hirschwald, 1878).

Magnesium Nitride.—Mallet obtains this compound by burning the metal in a limited supply of air. The band of magnesium when ignited is to be held well down in a porcelain crucible. If filings of the metal be used the same result is obtained, and with far greater completeness. The residue has a well-marked greenish-yellow colour, and evolves abundance of ammonia when moistened with water or a solution of a caustic alkali. When only a few drops of liquid are added the heat evolved is sometimes so great as to ignite a portion of the mass, and much of the powder is scattered by the escaping ammonia and aqueous vapour. In three analytical estimations of the results of the reaction it was found that 23·5, 27·5, and 24·8 per cent. of nitride were respectively formed.—*The Chemical News*, 1878, xxxviii. p. 39.

The Dissociation of Sulphides.—The hydrates of metallic sulphides are decomposed by water when boiling, as well as at lower temperatures, sulphuretted hydrogen being evolved and a metallic oxide formed. This is true of the majority of the sulphides, those of copper, bismuth, and mercury proving exceptions. Arsenic trisulphide is dissociated at the boiling-point into hydrogen sulphide and arsenious acid. De Clermont and Frommel have devised a method for the separation of arsenic from metallic sulphides which is based on this reaction. The mixed sulphides are to be suspended in water and boiled. The dissociation is soon complete. If the mixture weigh 5 to 6 cg. the liquid should be boiled from twenty to twenty-five minutes. All remaining sulphides give insoluble oxides, which can readily be separated from the soluble arsenious acid.—*Bull. Soc. Chim.*, Paris, 1878, xxix. p. 290.

The Solubility of Bottle-glass.—Macagno has determined the degree of solubility in water of a number of specimens of bottle-glass derived from different sources, and ascertained in each case "the corrosion degree" of a boiling solution of potassium bitartrate. He finds that the chemical composition of bottle-glass is hardly a correct indication of its quality. The amount of alkali or lime does not express the resisting power of the glass to water or acids. While the French glass is of very superior quality, the Rhenish, Madeira, Malaga, and Xeres bottles appear to have a very inferior composition. In order of colour we must set deep green in the first rank, in the second the white and common green, then the clear green, next the red-brown, while the worst are the yellow-brown, which must be regarded as likely to contaminate ordinary wines containing much potassium bitartrate. In the case of the deep green glass of a Burgundy bottle the corrosion degree was 1·275; white glass, used for Rhenish, Bordeaux, and

Chianti, 2·020; common green glass, used for Rhenish, Bordeaux, Champagne, &c., 3·202: yellow-brown glass, used for Bordeaux, Madeira, Malaga, &c., 3·387; and the red-brown, used for Rhenish, Ruster, Rohitscher, &c., 4·888.—*The Chemical News*, 1878, xxxviii. p. 5.

The Solubility of Platinum in Sulphuric Acid.—Scheurer-Kestner has continued his inquiry into the solubility of this metal in concentrated sulphuric acid, and finds that while the action of a 95 per cent. acid is a very marked one it becomes still more notable when the concentration exceeds that corresponding to the monohydrate. With the hope that platinum apparatus might be adapted to the manufacture of Nordhausen acid on a large scale, sodium bisulphate was fused in a glass retort lined with platinum foil, and the vapours were condensed in stone vessels. A number of experiments were made in this way with an apparatus the platinum of which weighed 5 kilog., and it was found that for every 100 kilog. of acid distilled 100 grammes of metal were dissolved in the sodium sulphate. In the earlier experiments 100 kilog. of 94 to 99 per cent. acid dissolved 1 to 8 grammes of metal.—*Comptes rendus*, 1878, lxxxvi. p. 1082.

Invertin.—This, the inverting constituent of yeast, to which Donath gave the above name, has been submitted to a long investigation by Barth (*Ber. Deut. Chem. Gesell.*, 1878, xi. 474). To obtain it he coarsely pulverises fresh compressed yeast and dries it at temperatures not exceeding 40° until it can be rubbed to powder between the fingers; it is then heated to 100° or 105° for six hours, mixed with water in considerable quantity, and after having been allowed to stand for twelve hours at 40° the insoluble portion is removed by filtration. The filtrate, which has a yellowish hue, is poured into six times its volume of alcohol containing 95 per cent.; this causes the formation of a white flocculent precipitate, which when violently agitated becomes granular, and then may easily be collected on a filter. The albuminates which are likewise thrown down by the alcohol can be removed by treating the precipitate with a limited amount of water, when they remain undissolved as a gelatinous mass. A second treatment with alcohol yields the ferment in a pure state. Two grammes of the ferment are obtained from 500 grammes of yeast. Invertin is a white powder, which dissolves in water, forming a yellowish-brown solution; this is not rendered turbid when boiled with acetic acid and salt, and is thus shown neither to be an albuminate nor to contain one as an impurity. When boiled with dilute copper solution and sodium hydrate it does not strike a violet colour; this indicates an absence of peptones. After heating some for a long time with sulphuric acid no leucin could be found. Analysis showed invertin to contain 22 per cent. of ash, consisting of potassium, calcium, and magnesium phosphates. If the inorganic constituents be excluded, the ferment contains: carbon, 33·9 per cent.; hydrogen, 8·4 per cent.; nitrogen, 6·0 per cent; sulphur, 0·63 per cent.; and oxygen (by difference), 41·17 per cent. The activity of invertin appears to be dependent on the degree of concentration of the sugar solution, and is proportional to the amount of ferment present; it reaches its limit in about forty hours. One part of invertin can produce 760 parts of inverted sugar.

Tinfoil and Tinplate.—Kopp and Engel have recently examined specimens of the tinfoil used in packing French chocolate. Traces only of lead were

found, and the composition of the metal, they consider, contrasts favourably with the so-called tin used for similar purposes in England. We find, however, that one sample of the foil which they analysed contained 6·111 per cent. of antimony and 0·889 per cent. of arsenic. The metal which coats "tin-plate" is more easily attacked and dissolved than is generally supposed. Menke detected the presence of 0·1513 gramme of tin in a "canned" pine-apple weighing 1¾ lbs., 0·0101 gramme of that metal in a tin of lobster, and 0·0067 gramme in one of apples.

GEOLOGY AND PALÆONTOLOGY.

A new Pre-Cambrian formation.—Dr. Hicks, whose establishment of the Dimetian and Pebidian formations we noticed last year (*P. S. Rev.*, N. S., Vol. I., p. 96), states in a communication to the British Association that he has found that the Pre-Cambrian rocks occupy many areas in Wales, and that they resolve themselves into three well-marked types, which he regards as separate formations, as they prove on examination to be unconformable to each other. At St. David's granitoid rocks occur at the base; resting unconformably upon these come quartz-felsites; which again are succeeded by the agglomerates, breccias, greenstone-bands, and schists of the Pebidian group. In North Wales the same order of succession was observed, but the middle, or quartz-felsite group, was more largely developed in Caernarvonshire, and hence Dr. Hicks proposes to name it *Arvonian*, from the Roman name of the district (Arvonia). The name is appropriate, as many of the mountains of Caernarvonshire consist of these rocks. Dr. Hicks thus distinguishes these Pre-Cambrian formations, namely:—

1. *Dimetian*, granitoid gneiss rocks.
2. *Arvonian*, quartz-felsites and porphyries (Halleflinta of Torel; petrosilex rocks, Hunt).
3. *Pebidian*, green and purple agglomerates and breccias, green chloritic schists, with massive greenstone bands, talcose schists, &c.

In these formations the bedding is usually easily recognized, but the actual stratigraphical thickness cannot yet be precisely estimated, although, from the sections exposed, Dr. Hicks infers that each of them must be many thousand feet thick, and their horizontal extension is also evidently very wide.

Fossil Mammals of South America.—From an examination of numerous remains of Mammalia, lately brought to Paris from Brazil and La Plata, M. Paul Gervais has obtained some important results. He regards *Toxodon* as nearly allied to the Porcine Mammals, and as probably agreeing with the Hippopotamus in its habits; but although it resembles that great old-world Pachyderm in some of its characters, it possesses others which indicate that it must have nearer allies which are still unknown. The Solidungula have no well-marked representatives from the region of La Plata, except the horses known as *Hippidia*. No remains of Tapirs have been found with these; but a fragment of the symphysis of a mandible, having traces of two canines with two incisors between them, seems to indicate an animal resembling *Rhinoceros* in this part of its dentition.

A large *Machairodus*, of which a nearly complete skeleton has been obtained, differs from the great Brazilian species (*Machairodus neogæus*) in the form of the skull, and in having only two instead of three lower molars. M. Gervais proposes to call it *M. necator*.

The remains of Glyptodonts confirm the separation of those animals into several genera, as proposed by Burmeister. One of them is described as a new species under the provisional name of *Glyptodon rudis*, but the author is of opinion that it will constitute the type of a new genus. Its bony plates are quadrangular and rough on the outer surface, but without rosaciform tubercles, and without radiating lines. The rings of the caudal sheath are composed of separate pieces, which interlock after the same fashion as the dorsal plates. Another undescribed species, of which only a small portion has been brought, seems to be nearly allied to *Hoplophorus*, but is distinguished from the known species of that genus by its bony plates, which consist of a smooth central polygonal disc with blunt angles, having on its sides smaller smooth plates in the form of arcs of a circle. The author names this species *Hoplophorus discifer*. M. Ameghino, one of the collectors of these fossils, has also obtained in the La Plata region numerous objects of human workmanship, some of which are believed to date back to the period of the great extinct Mammals. (*Comptes rendus*, June 3, 1878.)

An American Jurassic Pterodactyle.—Professor Marsh describes (*Silliman's Journal*, September 1878), the first indication of a Pterosaurian from American rocks older than the Cretaceous, the species found in which are generally of gigantic size, and so far as is known belonged to that toothless group of these reptiles which Professor Marsh proposes to name Pteranodontia. The specimen now described is from the "Atlantosaurus beds" (Upper Jurassic) of Wyoming, which have lately yielded the remains of so many interesting forms of reptiles. It is the distal portion of a metacarpal bone of the right wing, and indicates a Pterodactyle with an expanse of wings of four or five feet. Its shaft shows an oval section, but near the condyle becomes subtrihedral, with a distinct ridge on the under surface. It is hollow, with thin, smooth walls. The outer condyle is placed obliquely, as in the Cretaceous species; the lower groove between the two condyles is unusually narrow; and the inner condyle is nearly circular in vertical outline. The fragment presents no characters by which its generic relations can be established, and Professor Marsh describes it under the provisional name of *Pterodactylus montanus*.

Geology of Sind.—Mr. W. T. Blanford has communicated to the Asiatic Society of Bengal ("Proc.," January 2, 1878) some notes on the geology of Sind, a map of which has just been completed by the Indian Survey. The greater part of the province consists of the alluvial flat of the Indus, but in the west ranges of hills occur containing Tertiary and, as is now believed, Cretaceous rocks. A thin flow of basalt supposed to represent the Deccan traps underlies the undoubted Tertiaries. Mr. Blanford gives the following table of the beds of Sind:—

Name	Sub-divisions	Approximate thickness	Supposed Geological age	Remarks
1. ALLUVIAL, &c.	—	Unknown	Recent and post-tertiary	—
2. MANCHHAR .	Upper . . .	5,000	Pliocene	Apparently representative of the Sevaliks proper
	Lower . . .	3,000 to 5,000	Lower Pliocene or Upper Miocene	—
3. GAJ	—	1,000 to 1,500	Miocene	—
4. NARÍ . . .	Upper . . .	4,000 to 6,000	Lower Miocene	—
	Lower . . .	100 to 1,500	Upper Eocene	—
5. KHIRTHAR .	Upper . . .	500 to 3,000	Eocene	Nimmulitic Limestone
	Lower . . .	10,000 (?)	Eocene	Base not determined
6. RANIKOT . .	—	2,000	Lower Eocene	—
7. TRAPS . . .	—	40 to 90	Upper Cretaceous	Representative of Deccan and Malwa Trap
8. CRETACEOUS .	*Cardita Beaumonti* beds. .	350 to 450	Cretaceous	—
	Sandstones .	700		—
	Hippuritic Limestone .	320		Base not exposed

The most interesting point in this investigation is the asserted discovery of Cretaceous rocks in the hills of Western Sind. The lowest bed, the Hippuritic limestone, has only been found in one spot, and there the outcrop is not more than half a mile in length. The only recognizable fossil found was a Hippurite. This limestone is believed to be identical with the Cretaceous limestone which occupies a large area in Persia, and has been traced at intervals from south-east of Karmán to near Teherán. If so, this is the first recognition of the formation in India except in the Himalayas. The sandstones above the limestone are dark, often calcareous, and not very fossiliferous. Towards the top they contain oysters and a few apparently reptilian bones. Above these are olive clays, shales, and sandstones, containing a peculiar globose *Cardita* (*C. Beaumonti*), two or three species of *Nautilus*, and corals. The thin bed of trap has been traced for about 22 miles, always above the olive clays and beneath the lowest Tertiary beds; the author regards it as undoubtedly identical with the trap of Málwa and Guzerat. The Ranikot group in its lower portion contains only imperfect plant remains; but the limestones intercalated in its upper part abound in Mollusca, Echinodermata, and Foraminifera. Many of the fossils pass up into the overlying Khirthar beds, including *Nummulites Leymeriei*, the only abundant nummulite here. A few species show Cretaceous affinities, especially a *Salenia* and some *Nautili*. The Khirthar group is more widely distributed, and where best developed is the most conspicuous formation in the provinc

consisting of massive whitish and grey limestone, abounding in nummulites and other Foraminifera, associated with corals and mollusca. The commonest species are *Nummulites granulosus*, *biarritzensis*, *Leymerici*, *spira*, *Ramondi*, and *obtusus*, *Alveolina ovoidea*, *Orbitoides dispansus*, and *Nerita Schmidelsiana*. The Nari beds also contain nummulites, but not of the Khirthar species, which are replaced by *N. garansensis* and *sublævigatus* and *Orbitoides papyraceus*. The Gáj group is highly fossiliferous, but no nummulites have been found in it; an *Orbitoides*, apparently *O. papyraceus*, occurs. The Manchhar, or highest Tertiary, is of great thickness, and probably represents the Sewaliks of Northern India, but the genera of mammals are generally older, forms like *Dinotherium* and *Merycopotamus* prevailing.

The Urus Stage in Siberia.—M. J. Schmalhausen ("Bull. Acad., St. Petersb. tome xxv. p. 1) records the occurrence in Eastern Siberia of beds belonging to the infracarboniferous series denominated by Professor Heer the "Urus Stage," on account of their having first been recognized by him in Bear Island. The existence of such deposits had been previously indicated by the author on the evidence of fossil plants obtained from travelled blocks, one of which he identified with *Cyclostigma kiltorkense*. The rocks containing plants characteristic of the Urus Stage have now been found *in situ* in various places in the Government of Jenissei, chiefly in the banks of the river of that name and its affluents, as far south as 53° N. lat. The most important locality is the Issyk mountain, on the right bank of the river Abakan, near its junction with the Jenissei, which consists chiefly of a mass of reddish-brown sandstones, with interstratified greenish sandstones, overlain by a lighter-coloured mass, formed by interstratified greenish sandstones, limestones, and yellowish calciferous sandstones. On the eastern and western slopes of the mountain these deposits are overlain by shales and sandstones, with beds of coal. The impressions of plants were obtained from the light-coloured sandstones and the coal-bearing shales, those from the latter being well preserved.

The principal plants obtained from this and other neighbouring localities, among which a mountain near the mouth of the river Trifonowa is the chief, are as follows:—*Bornia radiata*, Schimp., *Triphyllopteris Lopatini*, sp. n., *Neuropteris cardiopteroides*, sp. n., *Sphenopteris*, sp., *Lepidodendron Veltheimianum*, Sternb., *L. Wilkianum*, Heer, *Cyclostigma kiltorkense*, Haught., *Cordaites* (?) *palmæformis*, Göpp., *Cyclocarpus drupæformis*, sp. n., and *Samaropsis oblonga*, sp. n.

Currents of the Suez Canal.—M. de Lesseps has communicated to the Academy of Sciences ("Comptes rendus," July 22, 1878) the results of a series of observations worked out by M. Lemasson on the interesting question of the behaviour of the water in the great maritime canal. The author has treated in detail of the tides and currents of the Mediterranean and Red Sea at Port Said and at Suez, and their influence upon the waters of the Canal, and has also taken into consideration the question of the action of prevalent winds. It appears that Lake Timsah and the basin of the Bitter Lakes, the former in the middle of the line of navigation, the latter nearly at the middle of the southern branch of the Canal, constitute two great regula[illegible] which the tidal currents from the two seas respectively expire. Th[illegible]ith branches of the Canal are not, however, independent as

ds the movement of their waters. The dominant winds in this region from May to October, from the north and north-west, and raise the level of the waters of the Mediterranean at Port Said, whilst they se the mean level at Suez. The difference of level, which attains nearly ntimetres (almost 16 inches) in September, sets up, in summer, a cur- rom the Mediterranean to the Red Sea, which is interrupted by the but nevertheless carries a considerable volume of water from north to . In the winter, on the contrary, the south winds blow strongly, and ean level of the Red Sea is then higher than that of the Mediterranean, ifference attaining a maximum of 30 centimetres (almost 1 foot). eneral direction of the current of the Canal then sets from the Red o the Mediterranean. The volume of water flowing annually from ea to the other is estimated at about 400,000,000 cubic metres, and with the tidal currents, annihilates the effects of evaporation at the e of the lakes, and aids the solution of the great salt deposit in the of the Bitter Lakes, which, instead of increasing, as was expected by people, is actually diminishing, especially in the line of transit of ships. idal currents in the northern branch of the Canal between Port Said ake Timsah usually vary in velocity from 0·15 to 0·45 metre per l, but may attain 0·50 and 0·60 metre. Between Suez and the Bitter the width of the Canal being greater, the currents vary from 0·60 to netre per second, and may attain 1·30 metre.

MINERALOGY.

arite.—The results of earlier analyses of milarite show so great a dis- that Ludwig has been induced to submit a pure specimen of this al to analysis. The mean of his numbers are:—

Silicic acid	71·61
Alumina	10·67
Lime	11·65
Potash	4·66
Water	1·36
	100·35

determinations indicate $Si_{12}Al_2Ca_2KHO_{24}$ as that of milarite. rmak, who has investigated the optical properties of this mineral, finds rystal to consist of at least six individuals, combined with each other in ons inclined at about 120°: they resemble in this respect crystals of nite, witherite, &c. The individuals appear to be twinned upon a face , it seems, is to be regarded as *x P* and all the crystallographic observa- o far made point to milarite belonging to the rhombic rather than the onal system.—*Jahrbuch für Mineralogie*, 1870, p. 431.

Meteorite of Hungen.—Professor von Leonhard has described the rite that fell which was witnessed at Hungen, in the Province Ober- , on the 17th of May last year. A piece weighing 7½ grammes has been sent to the University collection at Giessen, where the whole rust. The mass of the stone is very soft, and presents numerous cavities: ons external portion of olivine and nickel-iron is to be seen scat- hroughout it. Microscopic examination shows the rock to consist of the

extent of one-half its weight of nickel-iron; the matrix is colourless and transparent. Tschermak, who has examined the specimen sent to the Vienna collection, finds it to closely resemble the stones which fell in such numbers at Pultusk in January 1868. The crust in the former case, however, is thicker. A careful examination of a section of the Hungen stone enabled Tschermak to detect the presence of particles of nickel-iron, some 1·5 mm. in diameter, as well as granules of magnetic pyrites. The mass of the stone contained abundance of chondra, some opaque and lustreless, consisting apparently of chromite or picotite, while the transparent ingredients are of three kinds: one the crystalline characters and optical orientation of which identified it with olivine; a second in granular fragments which appeared to consist of bronzite; and a third the angular particles of which had a finely foliated texture, resembling diallage or augite.—*Jahrbuch für Mineralogie*, 1878, p. 411.

Sodium Chloride.—Bertrand has described crystals of salt from the Soda Lakes of Egypt, some 1 cm. in diameter, which were either octohedra or octohedra combined with the dodecahedron and the cube. The majority of them were not transparent, and had a grey colour. Sodium chloride has been obtained in octohedra of very small size, and without any other planes, by crystallization from a concentrated solution saturated with sodium carbonate. —*Zeitschrift für Krystall. und Mineralogie*, 1878, p. 199.

The Rocks of the Island of Vulcano.—Cossa finds that the alum of this island contains a relatively large amount of the sulphates of cæsium, rubidium, thallium, and lithium, all of which salts are probably present in the form of alums; and it is stated by him to stand second only to the rare pollux of Elba as material for the preparation of cæsium compounds. The rocks overlying the alum beds appear to have furnished the cæsium and rubidium, which are present in them in the form of silicates. These have subsequently been converted into alums by the action of acid vapours. A reddish porous crystalline mass which collects on the floor of the crater contained considerable quantities of sulphates of lithium, cæsium, and thallium, only traces of rubidium and potassium, and, in addition, boracic acid, ammonium chloride, arsenic sulphide, and selenium sulphide. Cossa recommends antimony chloride for the separation of cæsium and rubidium, and states that Stolba's method with tin chloride did not yield satisfactory results in his hands. A gas escaping from a mineral water which bubbled forth near the crater consisted of carbonic acid, 79 vols.; nitrogen, 20·5 vols.; and oxygen, 0·5 vol. in 100 vols.—*Ber. deut. Chem. Gesell.* 1878, xi. p. 811.

The *Mineralogische Mittheilungen*, edited by Prof. Tschermak, since the issue of the first part in 1871, and published as a supplement of the "Jahrbuch der K.K. Geolog. Reichsanstalt," has ceased to appear; and in its place Prof. Tschermak will edit "Mineralogische und Petrographische Mittheilungen," which will be published independently, six parts to be issued each year. Two parts have already appeared. In addition to original articles they contain notices of memoirs which have appeared in other scientific journals.

Pseudobrookite and Szabóite.—Koch describes, under the name of pseudobro[illegible]ombic mineral from the Aranyer Berg, in Siebenbürgen, h[illegible]osition:—

Titanic acid	52·74
Iron peroxide	42·29
Alumina	Trace
Lime and magnesia	4·28
Loss by ignition	0·70
	100·01

The mineral is dimorphous with menaccanite or ilmenite. The crystalline form, habit, and the physical, and in certain respects also the chemical, properties of the mineral are those of brookite; but closer examination shows it not to be that mineral. Szabóite is a triclinic mineral, which closely resembles pyroxene in appearance. It is composed of:—

Silicic acid	52·35
Iron peroxide	44·70
Alumina	Trace
Lime and magnesia	3·12
Loss by ignition	0·40
	100·57

Chemical constitution and crystalline form at first sight recall babingtonite, but the resemblance is not supported by further investigation—*Mineralogische und Petrographische Mittheilungen*, 1878, i. 77.

PHYSICS.

Acoustic Repulsion.—It can be shown theoretically that the average pressure at the node in a column of air vibrating in stationary waves cannot be equal to zero as long as the amplitude of vibration is not infinitely small. M. Dvorak has made experiments in illustration of this fact. In a resonator open at one end, there is a node at the other. In the inside, near the closed end, there is greater pressure than outside. When such resonators are delicately suspended, and turned towards the source of sound, or the resonant box of a tuning-fork, the repulsion is so great that it is apparent even with an ordinary brass Helmholtz resonator, weighing with its counterpoise 142 grammes.

An "Acoustic Mill," showing continuous rotation, was made by fastening from very light paper, or thin glass, resonators on the arms of a light wooden cross, balanced on a glass cap, with their openings facing the same way towards the source of sound. Rapid rotation is obtained by using a large Knadt's tube as the source. If a cone of stiff paper be held with its large extremity towards the sounding body, and of such a size that it vibrates to the same note, on excitation, a current of air rushes from the smaller end with such violence as to be felt and heard, and to blow out a candle at the distance of 20 centimètres. It appears that these experiments had been independently made, and indeed anticipated, by Professor A. M. Mayer, of New York.

In a paper on the Physical Origin of Nebulæ, Dr. Croll endeavours to fathom the origin of the sun's heat. It must be ultimately derived either from gravitation or from motion in space: but whereas the former source of energy could not have exceeded from 20 to 30 million years' supply of heat at the present rate of radiation, the store derivable from motion in space dependent on the *rate* of that motion may conceivably have amounted to any assignable quantity. A mass equal to that of the sun, moving with a velocity of 476 miles per second, possesses energy sufficient to cover the present rate of the sun's radiation for 50 million years.

This motion of translation must be converted into molecular motion by *collision*. The only assumption the collision theory makes is the existence of matter and motion. Suppose two bodies, each one half the mass of the sun, approaching each other directly at the rate of 476 miles per second, their collision would transform the whole of the motion into heat, affording an amount sufficient to supply the present rate of radiation for 50 million years. Each pound of the mass would, by the stoppage of the motion, possess as much heat as would melt 90 tons of iron. The whole mass would be converted into an incandescent gas, with a temperature of which we can form no adequate conception—certainly more than 140,000 times that of the voltaic arc.

Effect of change of pressure on the length of disruptive discharge in air.—Mr. J. E. H. Gordon has been studying this at distances ranging from 6 to 30 inches by means of the same apparatus. This was a fine induction-coil, giving a spark of 17 inches long, worked by 10 cells of a Grove's battery. The discharging tubes were 4 feet long, and 3 inches in diameter, with a stuffing box at one end in which a brass rod slid. The inner end of the rod was kept in the axis of the tube by three little glass arms on an ebonite collar. The whole was insulated on ebonite legs. The tubes were connected with an air pump by means of an insulating glass tube. The pressure was given by a U guage about 4 feet high, and the air dried by passing it through sulphuric acid.

In the experiments one tube was left open to the atmosphere, and its discharging point placed at a standard distance from the ball. The other tube being nearly exhausted, experiments were begun at low pressure, a little air being let in between each observation. The discharging distance in the second was then adjusted to the shortest distance which caused the whole discharge to pass in the first tube. This being noted, the points of the second tube were again brought together until the whole discharge passed between them. The mean distance of the two observations was used.

The results were:—

1. From a pressure of 11 inches upwards the length of spark is inversely as the pressure.

2. Accidental circumstances materially modify the length of spark.

3. Below a pressure of 11 inches the spark is shorter than it should be by No. 1, the electro-motive force required to produce a spark of given length at low pressure being greater.

This agrees with Sir W. Thomson's experiments, from which it results that greater electro-motive force per unit length of air is required to produce [illegible] distances than at long. To this may now be added, at low [illegible]igh. The cause seems to be unexplained.

The Harmonic Engine.—One of the most remarkable of Mr. Edison's many inventions is the so-called harmonic engine, which consists primarily of a large tuning-fork put into vibration by means of an electric current. With a small battery and a couple of electro-magnets, Mr. Edison has succeeded in getting sufficient power out of the vibrations of this "tuning-fork" to pump up a considerable quantity of water to the top of his house, to drive a sewing-machine, or to perform other work requiring small power. The "fork" consists of a couple of limbs, 2½ feet long, made of 2-inch square steel, the curved part being firmly held in a casting bolted to a solid foundation. Attached to the end of each arm is a 35lb. weight, and near each is a small electro-magnet, possessing sufficient power to set the arms in vibration. These vibrations, which are made at the rate of 35 per second, are of small amplitude, but are of sufficient power to work a little pump, the rapidity of the motion compensating for the smallness of the stroke. The machine is at present little more than a toy, but, its effectiveness having been demonstrated, further developments may render it a useful motor for employment in domestic work. Mr. Edison proposes to utilize the machine for compressing air, but it will probably be found more profitable to employ the power direct, instead of using it through that agency, the machinery for which must of necessity absorb a considerable quantity of the power in overcoming friction.

ZOOLOGY.

The Buzzing of Insects.—It has long been supposed that the buzzing of bees, flies, and other insects, was due to the friction of the air passing through the thoracic stigmata, after being set in motion by the action of the muscles moving the wings. After repeating the experiments on which this opinion is founded, M. Pérez comes to a different conclusion. He finds that when the wings of a fly are held so tightly that no motion of their bases is possible, no sound is produced; but, on the other hand, the removal of the scaly portions fringing the periphery of the stigmata, injury to the margins of the stigmata themselves, and stopping them with solid masses, leaves the buzzing unaltered, and even a hermetical closure of these apertures has only the effect of weakening the sound produced. In this last case the power of flight is weakened, owing, according to M. Pérez, to an asphyxia of the insect caused by the exhaustion of the air in the thoracic tracheæ, which is after a time made up by an influx of air from the abdomen, but the attempts at flight become weaker and weaker, and the animal speedily dies.

M. Pérez's interpretation of these phenomena is that the causes of buzzing reside solely in the wings. Cutting the wings influences the buzzing more or less, this becoming thinner and sharper and losing the softness due to the friction of the air upon the edges of the wings. The sound is different according to the amount of the wing removed, that is to say, the shortness of the stump, and it is in relation with the beatings of the stump against the solid parts which surround it, or of the horny pieces which it contains one against the other. If the section be carried down to sensitive parts the sound ceases; but this is because the animal ceases to perform movements which have become painful to it.

Of various buzzing insects the author says that, in the Hymenoptera and Diptera the buzzing is due to two distinct causes, namely, the vibrations of which the articulation of the wing is the seat, the true buzzing, and the friction of the wings against the air, which modifies the former more or less. In strong-winged Lepidoptera, such as the Sphingidæ, the buzzing is produced entirely by the friction of the air upon the wings; so also with the dragon flies.—(*Comptes rendus*, 2 September, 1878.)

Drone-Bees.—It is well known that, according to a theory of M. Dzierzon adopted and developed by Professor Siebold, the eggs from which drone-bees are produced in a hive are deposited by the queen without fecundation, and that the queen-bee can even fecundate the eggs or leave them unfertilized, according as they are intended to produce females or males. The theory was founded, at least in part, upon the supposed fact that an Italian queen, fertilized by a German drone, would produce hybrid-workers and queens (females) and drones exactly like herself. M. Pérez, however, disputes the genuineness of this fact, on the ground of observations made upon a hive in his possession, the queen of which, the daughter of an Italian of pure race, has been fertilized by a French drone. Some of the workers are Italian, others French, others mixed in various proportions of the two races. Among the males also he observed some as dark as those of the French race, although, according to the above theory, they ought all to have been of the Italian race, like their mother. He therefore carefully examined 300 of the drones, and obtained the following numbers:—

151 were pure Italians.
60 were hybrids of various degrees.
83 were French.

Hence he regards it as evident that the drone-eggs, like those of the females, are fertilized by contact with the fluid stored up in the seminal receptacle of the queen, and that Dzierzon's theory must fall to the ground. This theory, however, was supported by other facts and experiments; and it is a question whether M. Pérez's queen which he speaks of, guardedly, as the 'fille d'une Italienne de race pure,' was herself of pure Italian race.—(*Comptes rendus*, 9 September, 1878.)

Prosopistoma.—MM. Joly & Vayssière have examined the structure of this curious insect, only what appears to be the larval form of which is known, and the true position of which is consequently very doubtful ("Comptes rendus," August 5, 1878). In its form it resembles the Ephemeridæ, and especially the larva of the American *Bætisca obesa*, Say. It has the parts of the mouth usual in masticating insects. The respiratory system includes two kinds of organs: 1, the internal tracheal apparatus, represented by two main trunks, giving origin to numerous branches; 2, supplementary organs situated at the anterior part of the dorsal surface of the abdomen in a sort of cavity, the upper wall of which is formed by the thorax, and which communicates with the outer world by three openings—two placed laterally on the ventral surface, and a median aperture on the dorsal surface. This respiratory chamber contains a tracheo-branchial apparatus, consisting of five lamelliform or digitiform pieces on each side. These pieces move rhythmically, and ca[illegible]ntrance of water by the ventral apertures, and its escape by the [illegible] The authors give some details as to the internal structure of

the insects, and say that from the facts ascertained they are disposed to adopt Mr. McLachlan's opinion, that *Prosopistoma* is an Ephemerid, probably adapted permanently to an aquatic life.

Abnormal Dentition in a Tiger.—Mr. Lydekker describes and figures ("Journ. Asiatic Soc.," Bengal, 1878) the lower jaw of a tiger from Burma, in which a third premolar is developed on one side. The specimen is interesting, because in the extinct feline genus *Pseudelurus* the third premolar is always present. *Pseudelurus* was founded on a Miocene fossil from Sansan, in France, and other species have been described from the Pliocene of Nebraska, and from the Sevaliks.

Entoniscus in France.—Among the parasitic crustaceans described by Dr. Fritz Müller perhaps none was more curious than that to which he gave the name of *Entoniscus*, a true isopod crustacean, the female of which, after a short free life, took up its abode in the abdomen of a crab, and became converted into a great sac branching about among the viscera of its host. Hitherto these parasites have been only known to occur on the Brazilian coast, where they were studied by the distinguished naturalist above-mentioned; but M. Giard has now discovered two species on the coast of France, one of which, however, he believes to have been seen long since by Cavolini. The commonest of the two species, which M. Giard names *Entoniscus Cavolinii*, is found under the carapace of *Grapsus marmoratus*, Fab., an abundant species on the rocks at Pouliguen, Loire-Inférieure; and the parasite is so numerous that out of thirty crabs one will usually be found to bear it. The second species is much less common, occurring only in about 1 per cent. of the crabs on which it is parasitic, the Velvet Crab (*Portunus puber*), a British species. To this M. Giard gives the name of *Entoniscus Moniezii*. It is unnecessary here to indicate the characters of the species, but some remarks of M. Giard's upon the active embryo of *Entoniscus Cavolinii* are of considerable interest. He finds that, besides the lateral eyes, which are double and correspond to the eyes of the normal isopods, the embryo possesses a median eye, composed of two contiguous crystallines, with pigment and optic nerves. This he regards as the Nauplian eye, which has persisted, retaining a structure such as is met with in many copepods, and which afterwards disappears with the secondary eyes during the retrograde metamorphosis of the female *Entoniscus*. This fact is of special importance, if it is a real trace of the occurrence of a Nauplius stage in the development of this curious isopod. (*Comptes rendus*, September 2, 1878.)

Circulation in Insects.—Mr. S. H. Scudder has read before the Boston Society of Natural History (*Proc.* vol. xix. part 1), some remarks upon the circulation of insects, a subject upon which, as he justly says, many contradictory views have been held. He says the juices of the digested food appear to pass directly through the thin walls of the alimentary canal into the general cavity of the body; from this they are pumped into the hinder extremity of the pulsatory dorsal vessel, by its alternate contractions and dilatations, while in many cases portions also appear to enter the sides of the vessel just in advance of the valves which aid the pulsating action by allowing a free passage to the fluid only in a forward direction. In the larval state the walls of the pseudocardium are often so slight as to be scarcely perceptible; but they are distinct in the imago, and as the vessel contracts

towards the head of the larva its nature becomes more apparent. More than a century ago Lyonnet showed that the dorsal vessel of the goat-moth-caterpillar has only a single outlet for the passage of the fluids, namely, where it terminates with a flaring opening at the extreme front of the head, just above the base of the œsophagus, into a cavity closed by membrane. The direct passage of the fluids thence has never been observed, but they must in some way at once enter the passages surrounding the tracheæ, since they are next found circulating in these all over the body. Other writers have described the anterior extremity as branching, but in like manner have not traced the passage of the fluids beyond the main trunk.

Mr. Scudder remarks that the only large tracheal vessel connecting the two sides of the body lies in the first segment behind the head; and that according to the little-known investigations of Barthélemy,* this transverse tracheal conduit appears at the earliest formation of the system in the embryo, before any regular distribution of fluids over the body can be observed; from the middle line of this transverse trachea half a dozen or more prominent branches pass directly forward, and some, at least, of their branches penetrate the cavity into which the dorsal vessel empties its contents. It is, therefore, highly probable that through them the fluids enter the peri-tracheal system, for by this channel the fluids would pass in the easiest possible manner to every part of the body from the moment that the pulsations of the dorsal vessel commence in the embryo. This, therefore, is the principal point towards which it is desirable that future investigations should be directed; and especially the structure of the tracheal threads which enter this cavity should be minutely studied.

The tracheæ, as shown by several anatomists, consist of two entirely distinct parts, and although authors do not wholly agree in their explanation of the structure of the tracheæ, there appears to be little doubt that it is substantially as follows:—First, a main stem and its branches, in which, between investing tissues, lies a closely-coiled spiral thread; and outside of and enveloping which is the peri-tracheal vessel, whose outer walls are not limited by the extent of the tracheæ proper, but extend beyond the spiral coil to form the second and distinct part of the system, namely, capillary tubes, penetrating every portion and organ of the body, and terminating in a meshwork of interlacing branches. In other words, this portion of the circulatory system consists of branching tubes, which enclose within all but their ultimate ramifications the similarly branching tubes of the respiratory system. The fluids, therefore, forced by the dorsal vessel into the peri-tracheal cavities, become thoroughly aerated before passing into the tissues of the body to perform their functions; when they have done their work, they empty themselves into the general cavity of the body, and mingling with the fluids newly expressed from the alimentary canal, join the general currents, which, as first shown by Carus, appear to set in regular channels at the sides and floor of the body, often, however, with no vascular boundaries, towards the hinder extremity of the body, or towards the sides of the dorsal vessel, to enter again the initial point of the circulation.

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* "Recherches d'Anatomie et de Physiologie Générales sur la classe des Lépidoptères." Toulouse, 1864.

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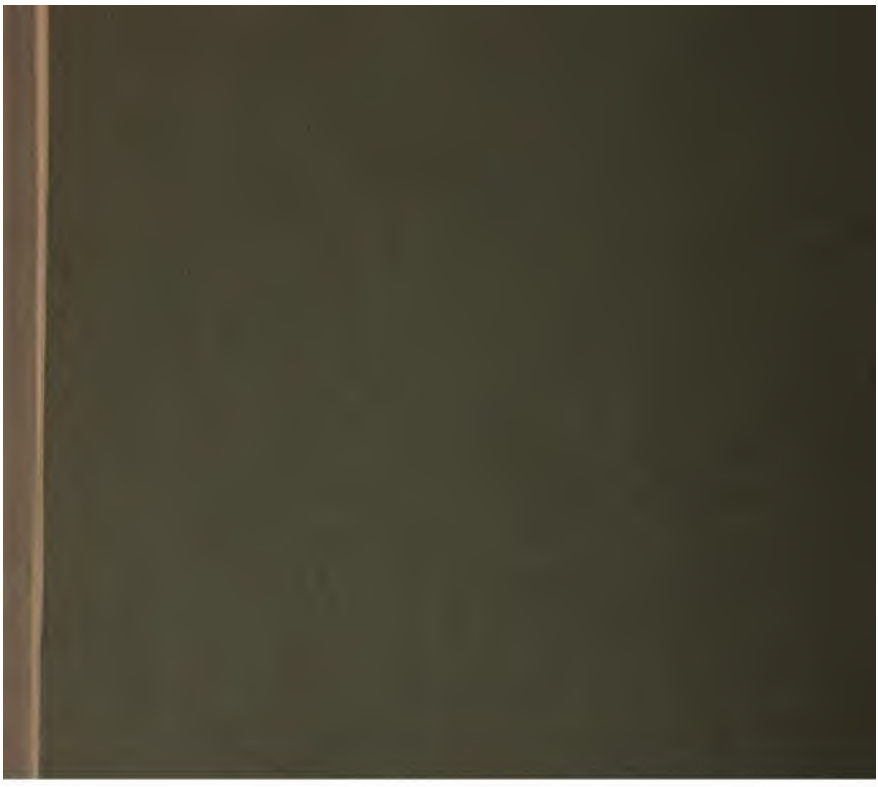

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